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Environmental, Electrical, and Electromagnetic-Compatibility Testing of the TFCC—DTC-II

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ADMINISTRATIVE INFORMATION

The work described in this document was tasked by the NCCS Afloat Program Office (Code 4306) to be performed by the Environmental and Electronic Test Branch (Code 951) of the Naval Ocean Systems Center. Sponsorship was provided by the Space and Naval Warfare Systems Command.

Released by
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Under authority of
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OBJECTIVE

Subject the Tactical Flag Command Center (TFCC) Desk-Top Tactical Support Computer (DTC) II to environmental, electrical, and electromagnetic-compatibility testing prior to installation on a shipboard platform.

RESULTS

<u>MIL-S-167</u>

Vibration Test—Unit 1 passed; Completed all axes. Two uninterruptable power supply (UPS) failures; Trackball failure. Unit 2 completed vertical axis. Both monitors failed at 23 to 25 Hz. Inner rack off-center—bezel impacting. Shims added to center inner rack. Retested and failed again at 23 to 24 Hz.

<u>MIL-S-901</u>

Shock Test—Passed. Two units tested; Nine shock blows each; Upper shock mount plate screws broke. Unit 2's inner cabinet hit outer cabinet.

<u>MIL-STD-810</u>

Humidity Test—Failed aggravated cycle; Extensive corrosion damage on printed circuit boards. Passed alternate 15-day induced test.

Salt-Fog Test—Material samples passed; No unusual corrosion.

High-Temperature Test—Failed at –40°C; Hard-disk failure at –30°C. Capable of passing at –20°C.

<u>MIL-E-16400</u>

Inclination Test—Passed 5 to 7 cycles per minute, 30 minutes, 35°. Operating, slides extended, two axes.

<u>MIL-STD-1399</u>

Power Input Tests—Passed.

<u>MIL-STD-461C</u>

Electromagnetic-Compatibility Test—Emissions in excess of limits; 10 dB above limit in CE02; 15 to 20 dB above limit in RE02.

SECTION 1

CONTENTS

FIGURES

TABLES

1.0 ENVIRONMENTAL AND ELECTRICAL TESTING OF THE TFCC—DTC-II

1.1 DESCRIPTION OF THE TEST ITEMS

Three DTC-IIs were used in the environmental and electrical testing, two single-monitor units and one dual-monitor unit. The single-monitor units are referred to here as units 1 and 3, and the dual-monitor unit is referred to as unit 2. The DTC-II is configured as a rack within a rack; the inner rack isolated from the outer rack by wire-rope isolators and the outer rack isolated from the ship by the same means. System components are mounted in the inner rack on slides for ease of servicing. The components include an uninterruptible power supply (UPS), a processor, a keyboard, various I/O devices, and one or two cathode-ray tube (CRT) monitors. The single-monitor rack weighs approximately 750 pounds, and the dual-monitor rack weighs about 950 pounds.

1.2 TEST SEQUENCE

The following test sequence was performed: (1) MIL-S-167-1, vibration; (2) MIL-S-901, shock; (3) MIL-STD-810D, high temperature; (4) MIL-STD-810D, low temperature; (5) MIL-STD-810D, humidity; (6) MIL-E-16400H, altitude; (7) MIL-E-16400H, inclination; (8) MIL-STD-810D, salt fog; (9) MIL-STD-1399, Section 300A, power input; and (10) MIL-STD-461C, electromagnetic compatibility.

2.0 ENVIRONMENTAL TESTS AND RESULTS

2.1 VIBRATION TEST

<u>Test Procedures</u>. Unit 1 was the first DTC-II to be vibration tested. Testing took place on the VARD mechanical vibration machine by using a bulkhead fixture to simulate the shipboard mounting configuration (figure 1). The tests performed were exploratory, variable frequency, and endurance as described in MIL-S-167-1. The front-to-back axis was tested first. Resonances were found at approximately 9 Hz and 17 Hz. The two-hour endurance vibration was, therefore, run for one hour at 9 Hz and for one hour at 17 Hz. Two problems were found: the trackball became nearly inoperable, and the safety interlock switch on the central processing unit (CPU) drawer occasionally cut the power as the drawer vibrated. The latter problem could be avoided by means of the "battle short" switch located above the CRT. Disassembly of the trackball assembly revealed that the plastic bracket, which holds one of three bearings in which the trackball rotates, had fractured.

The unit was next tested in the side-to-side axis. The only resonance found in this direction was at 15 Hz. The exploratory, variable frequency, and endurance tests were completed with no additional failures. The trackball had not been replaced at this point.

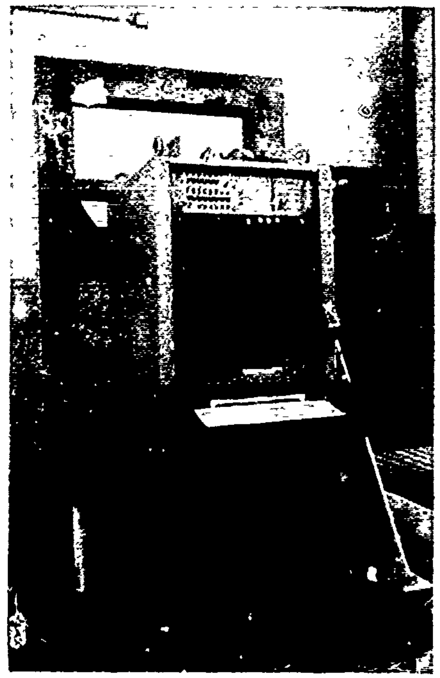

Figure 1. Unit 1 on the vibration tester.

The unit was then tested in the vertical axis. Following the completion of the exploratory test, the variable frequency test was begun. After the 13-Hz dwell, the system was secured for the day. The trackball was completely inoperable and a new trackball was wired in but not installed in the keyboard. The trackball was placed on a piece of foam on the floor adjacent to the vibration machine. The variable-frequency test was then completed without further problems. Approximately 3 seconds after the 13-Hz endurance test was started, a puff of smoke and a loud noise were emitted by the UPS. The vibration was stopped and the DTC-II shut down to investigate. Pulling out the UPS drawer and opening the top revealed that a loose screw had rubbed through the coating on a printed circuit (PC) board and caused a short (figures 2, 3). As this was clearly a quality-control-related failure, the test could be restarted from the stop point following repairs. The UPS was replaced with a spare and the testing resumed. The 2-hour endurance test was started again and, after 67 minutes, the DTC-II shut itself down. The vibration was halted to investigate the failure and the problem was again traced to the UPS. At this time, the UPS from unit 2 was installed in unit 1 as no more spares were available. The 2-hour endurance test was then completed without incident and the UPS replaced in unit 2. The two failed UPSs (serial numbers 1000162 and 1000053) were returned to the manufacturer, EPE Technologies, for failure analysis. Cursory information has been received from EPE indicating that one unit had a blown fuse in an auxiliary power supply and the other unit had a problem with a resistor on the main board. A more detailed analysis was not available at the time of this writing. Appendix A describes the EPE findings.

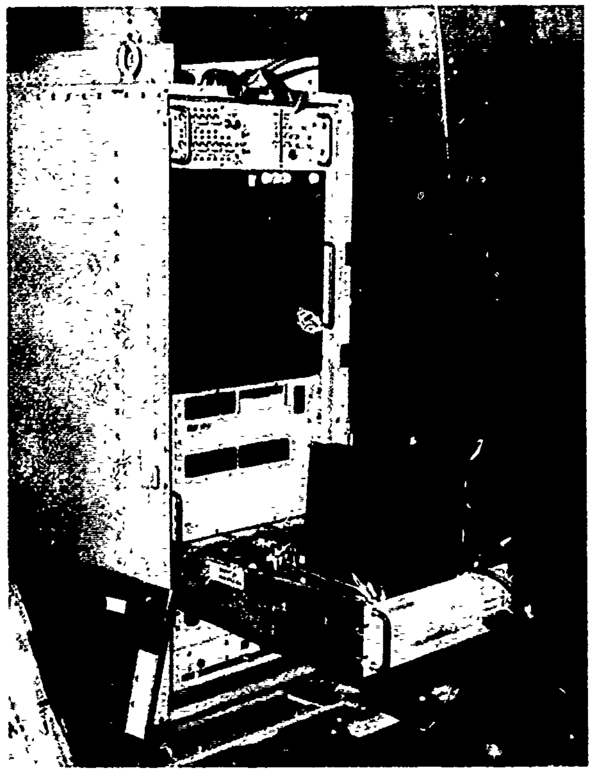

Figure 2. Unit 1 after the UPS failure.

Figure 3. Looking down into UPS.

Unit 2 was vibrated next. The vertical axis was done first and the exploratory, the variable-frequency, and the endurance tests were completed without failures. The display in the lower monitor showed some vertical black lines at about 24 Hz and horizontal black lines slowly drifting down the screen at about 15 Hz.

The side-to-side axis was next. The DTC-II would not boot after being powered-down overnight. The problem was traced to the CPU board. An integrated circuit (IC), U103, had a bent pin. The IC had apparently made contact well enough for the system to boot the previous day, but the vertical vibration had caused it to lose contact. The bent pin was straightened and the chip reinserted, after which the system booted normally. The test was then started and the exploratory completed with a resonance noted at 15 Hz. The next test, the variable frequency, proceeded uneventfully through 23 Hz. During the 24-Hz dwell, the upper monitor failed. During the 25-Hz dwell, the lower monitor failed. The test was temporarily halted. The inner rack was off center in the outer rack, and the bezel around the upper monitor was impacting the outer rack near the upper left corner of the monitor. Shock-Tech, Inc. installed a shim to center the inner rack in the outer rack. New monitors were installed and the side-to-side vibration test was restarted. The exploratory test was completed uneventfully and the variable-frequency test started. During the variable-frequency test, observation of the inner rack's position relative to the outer rack revealed no impacting. At 23 Hz, the upper monitor failed and, at 24 Hz, the lower monitor failed. At this time, the test was stopped.

Results. Unit 1 completed the full MIL-S-167-1 vibration-exposure test with failures of the trackball assembly and of two UPSs. The JOTS II software cannot continue operation in the event of failure of the trackball. As the trackball is necessary to the operation of the system, this is a critical failure. One UPS failure was clearly caused by improper assembly, the cause of the other failure is under investigation.

Unit 2 did not complete the full MIL-S-167-1 vibration-exposure test. The unit completed the vertical-axis exposure but, during the side-to-side axis vibration, both monitors failed twice. As all four monitors failed at nearly the same frequency, this is probably a design-related failure rather than a workmanship problem. The first two that failed have been inspected by the manufacturer, SONY, Inc. The same transistor lead failed in both units. Cracked solder joints were found on the scan board of one of the other failed monitors (figure 4). Resoldering these joints did not resolve the failure. C3, Inc. picked up the monitors to perform failure analysis. Results of the failure analysis were received via FAX message (appendix A). The first two monitors referred to in the message (serial numbers 2048368 and 2047554) were two of the four that failed during the vibration test. The third monitor referred to (serial number 2051100), failed during the aggravated-humidity test. The cause of failure of the remaining two monitors that failed during vibration had not been reported at the time of this writing.

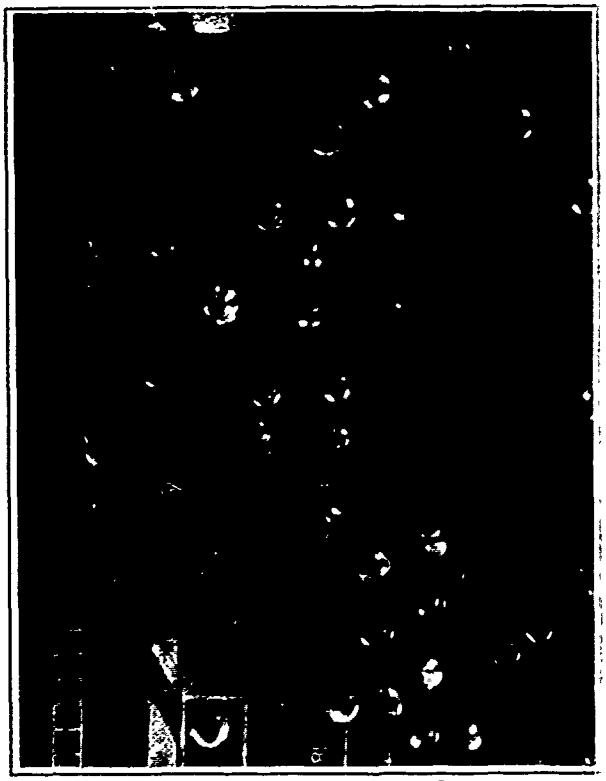

Figure 4. Cracked solder joints on the scan board.

During the vibration test, a hand-held strobe unit was able to stop the motion of both units. Aiming the strobe at the upper part of the rack caused the alarm to sound. The area where the "COAX-FIBER" toggle switch is located seemed to be the sensitive area. Operating the strobe in close proximity to this area did not cause the alarm to sound unless the light was pointed at the area. Blocking the light with a sheet of notebook paper was enough to prevent the alarm from being activated. A flashlight beam directed at the same spot did not cause the alarm to sound.

2.2 SHOCK TEST

Test Procedures. Units 1 and 2 were subjected to the MIL-S-901-D shipboard shock test. The units were tested to Grade A, Class 1, Type A requirements for deck-mounted equipment. The units were operational with the JOTS II software running during the shocks. Each unit received a total of nine shock blocks, three each with the unit oriented vertically, three each with the unit tilted forward 30°, and three each with the unit tilted sideways 30°. Figure 5 shows unit 1 in the vertical orientation, figure 6 shows unit 2 in the forward tilted position, and figure 7 shows unit 1 tilted sideways. High-speed video tapes were taken from two camera positions for each blow. Accelerometers were installed at twelve locations on unit 1 and at nine locations on unit 2. The data were recorded on magnetic tape and subsequently analyzed to provide velocity, displacement, and shock spectra for each instrumented location. Figure 8 shows accelerometer locations for unit 1. The first nine accelerometers were mounted in similar locations on unit 2 (figure 5). Plots of the acceleration data can be obtained from the author. There are two pages for each accelerometer for each shock blow. The first page contains four plots, the upper left is the raw acceleration data, the upper right is the acceleration low pass filtered at 200 Hz, the lower left is the velocity, and the lower right is the displacement. The second page contains the shock spectra, the solid line being the primary or maximax spectrum, and the dashed line the residual spectrum. The channel and blow numbers can be determined from the line directly below the words "Shock Response Spectrum" on the shock spectra plots. (e.g., "B DTC2-2B9 C 12 MAX..." where the "2B9 C 12" translates to Blow 9 Channel 12 and the "MAX...") lists the maximum response in the spectrum and the frequency at which it occurred. Note that this is not the same as the peak level in the time history. Peak relative displacement measurements were made between the outer rack and the baseplate. These measurements are summarized in table 1.

Figure 5. Unit 1 ready for shock in the vertical axis.

Figure 6. Unit 2 ready for shock in the 30° forward configuration.

Figure 7. Unit 1 ready for shock in the 30° sideways configuration.

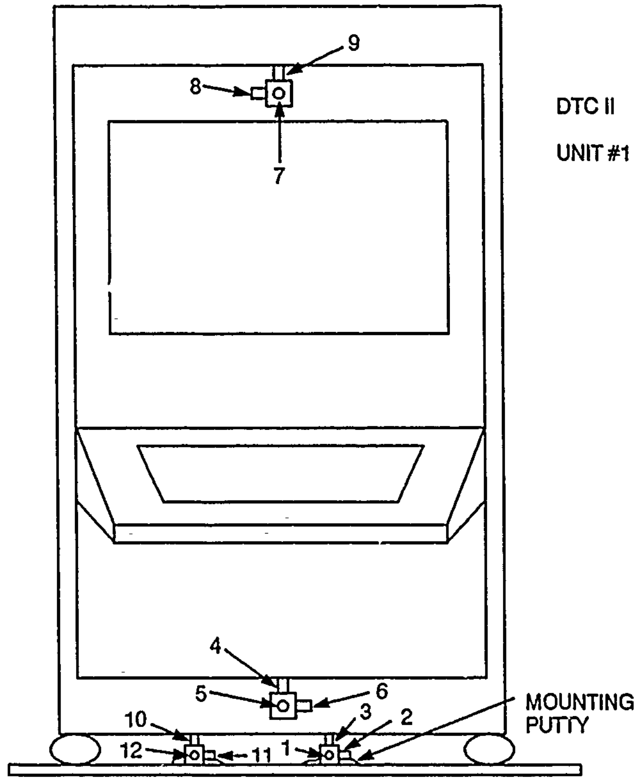

Figure 8. Unit 1 accelerometer locations for shock tests.

Table 1. Peak relative displacement measurements.

Unit	Shock Blow	Hammer Height	Table Travel	Configuration	Peak Relative Motion Front		Back	
1	1	1.5’	3”	Vertical	nm			
1	2	2.5’	3”	Vertical	1”			13/16”
1	3	2.5’	1.5”	Vertical	7/8”			13/16”
1	4	2.0’	3”	30 deg. forward	nm			
1	5	3.5’	3”	30 deg. forward	15/16”			5/8”
1	6	3.5’	1.5”	30 deg. forward	7/8”			1/2”
1	7	2.25’	3”	30 deg. sideways	1/2”			3/8”
1	8	3.75’	3”	30 deg. sideways	5/8”			1/2”
1	9	3.75’	1.5”	30 deg. sideways	3/8”			1/2”
					Lt.	Rt.	Lt.	Rt.
2	1	2.5’	3”	30 deg. sideways	1/2”	1/2”	nm	nm
2	2	4.5’	3”	30 deg. sideways	3/4”	3/4”	3/4”	5/8”
2	3	4.5’	1.5”	30 deg. sideways	5/8”	5/8”	5/8”	5/8”
2	4	2.25’	3”	30 deg. forward	5/8”	5/8”	5/1”	3/8”
2	5	3.75’	3”	30 deg. forward	5/4”	1”	7/8”	3/4”
2	6	3.75’	1.5”	30 deg. forward	nm			
2	7	1.5’	3”	Vertical	1/2”	5/8”	3/8”	1/2”
2	8	2.5’	3”	Vertical	1”	1”	3/4”	1/2”
2	9	2.5’	1.5”	Vertical	5/8”	3/4”	5/8”	5/8”

NOTE: "nm" in the table above means "not measured"

The above measurements were made by putting putty between the rails of the baseplate of the DTC-II in such a way that the putty would be crushed by the amount of compression of the wire-rope shock isolators. The dimensions represent the distance from the rail to the top of the putty after each shock blow. On unit 1, putty was placed in the approximate center of the front and rear rails. On unit 2, putty was placed as near the corners as possible. Typical putty location for unit 1 is shown in figure 9 just above the "NOSC" scale. Six of the accelerometers are also shown in this picture.

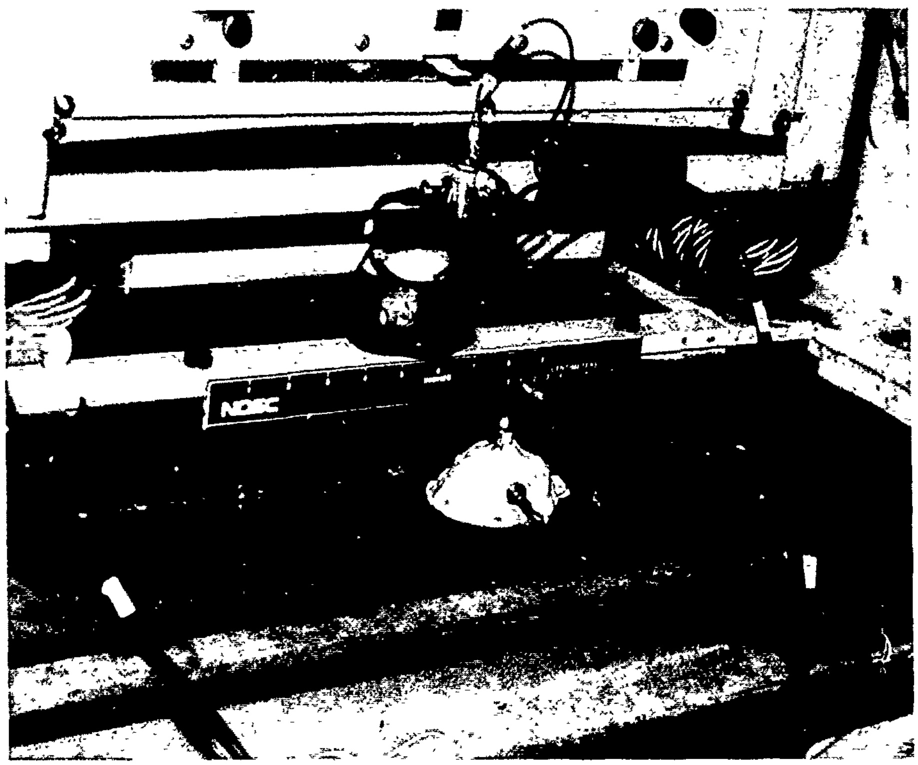

Figure 9. Front of unit 1 showing accelerometers ready for shock measurements.

Results. Both units experienced failures of the screws holding the upper shock mount plate to the back of the cabinet. The plates also bowed away from the cabinet as shown in figure 10. The original 10-32 screws on unit 2 were replaced after blow 5 with 1/4-20 through bolts with nuts and washers on the outside of the cabinet. These bolts survived the rest of the blows. During blow 8 on unit 2, the top of the inner rack collided with the top of the outer rack with enough force to bend the top plate of the outer rack and shear one of the screws holding the top on. Unit 1 reported problems with drive "SDOa" after blow 5 and had to be rebooted. No other operational problems were encountered with either unit.

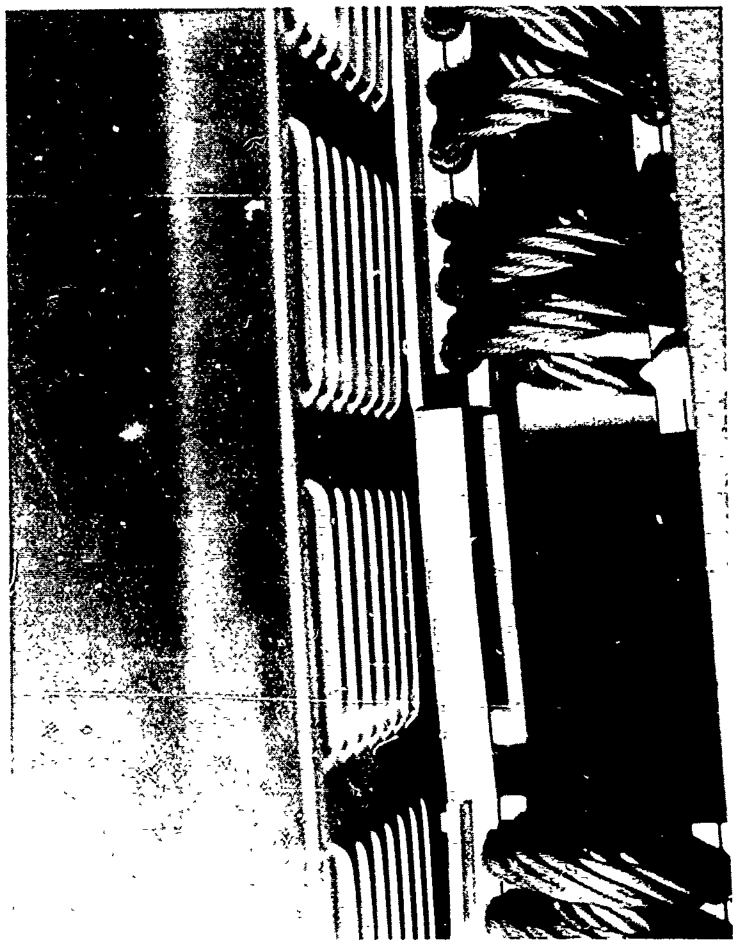

Figure 10. Looking up at the upper shock mount plate showing bowed metal after the shock tests.

2.3 HIGH-TEMPERATURE TEST

Test Procedures. Unit 2 was subjected to high-temperature testing as specified in MIL-STD-810D, Method 501.2, Procedure II as modified by MIL-E-16400 and SPAWAR. The unit was subjected to three 12-hour cycles between 49 and 60°C, then stabilized at 40°C for 6 hours. The test plan then called for the unit to be operated for 2 hours before operational checks were performed. However, because the unit would not boot, it was allowed to cool overnight to room temperature. It booted normally the next day so the chamber was set to 30°C and the unit left for a 6-hour soak, after which the unit again booted normally. A determination was made that the wrong high-temperature shutdown switch had been installed and was shutting the system down at 33°C, instead of the specified 55°C. Thus, the switch was bypassed before testing continued. The chamber was set to 40°C for an overnight soak after which the system booted and operated normally. The chamber was then set to 45°C, which caused the "WARM" warning light to illuminate on the DTC-II, but the unit continued to function normally. The chamber temperature was finally raised to 50°C for 4 hours and the unit continued to function normally. Figure 11 shows the chamber temperatures recorded during this test. Unit 3 was subjected to three 12-hour cycles between 49 and 60°C and then operated at 40°C. Figure 12 shows the chamber temperature history for this test. Unit 3 was then subjected to high-temperature testing with the upper limit of the test reset to 71°C rather than 60°C. The unit was subjected to 3 12-hour cycles with the temperature held at 49°C for 6 hours, then 71°C for 6 hours during each cycle. The unit was stabilized at 40°C for 6 hours, and then booted and allowed to operate for 2 hours after which it was shut down, rebooted, and operated. The system performed each of these operations without difficulty. Figure 13 shows the chamber temperatures recorded during this test. An operational test was next performed at 50°C after the unit had been exposed to 50°C for 6 hours and operated for 2 hours. It also passed this test without difficulty. Six thermocouples were installed in unit 3 and monitored during these tests. The thermocouple locations are listed in table 2.

Table 2. Thermocouple locations.

Channel	Location
1	Inside rear of CPU drawer
2	Inside front of CPU drawer
3	At rear of Megatek board
4	In air—1-inch below temperature sensor
5	On top of temperature sensor
6	At front of Megatek board

Figures 14 and 15 are graphs of data recorded during the high-temperature testing of unit 3. Figure 14 shows how the temperature inside the DTC-II lags behind the chamber air temperature by about 4 hours during the nonoperational storage cycle. Figure 15 is data recorded during high temperature (40°C) operation of the DTC-II. The temperatures inside are consistently higher toward the rear of the unit.

Results. The only difficulty during high-temperature testing of units 2 and 3 was the installation of the wrong high-temperature shutdown switches in both units. The switches had to be bypassed to do operational tests at temperatures higher than 30°C.

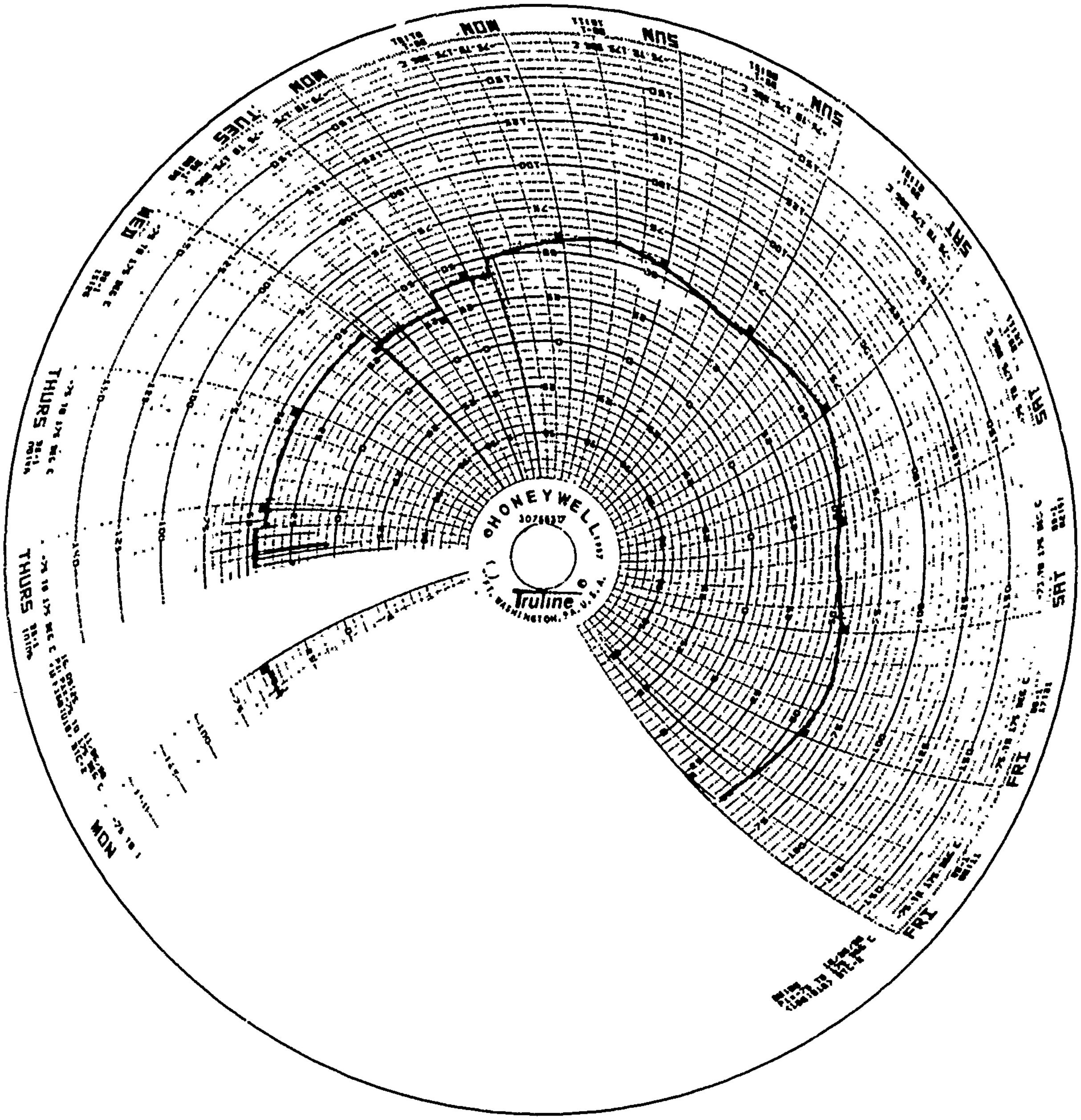

Figure 11. Original high-temperature profile for unit 2.

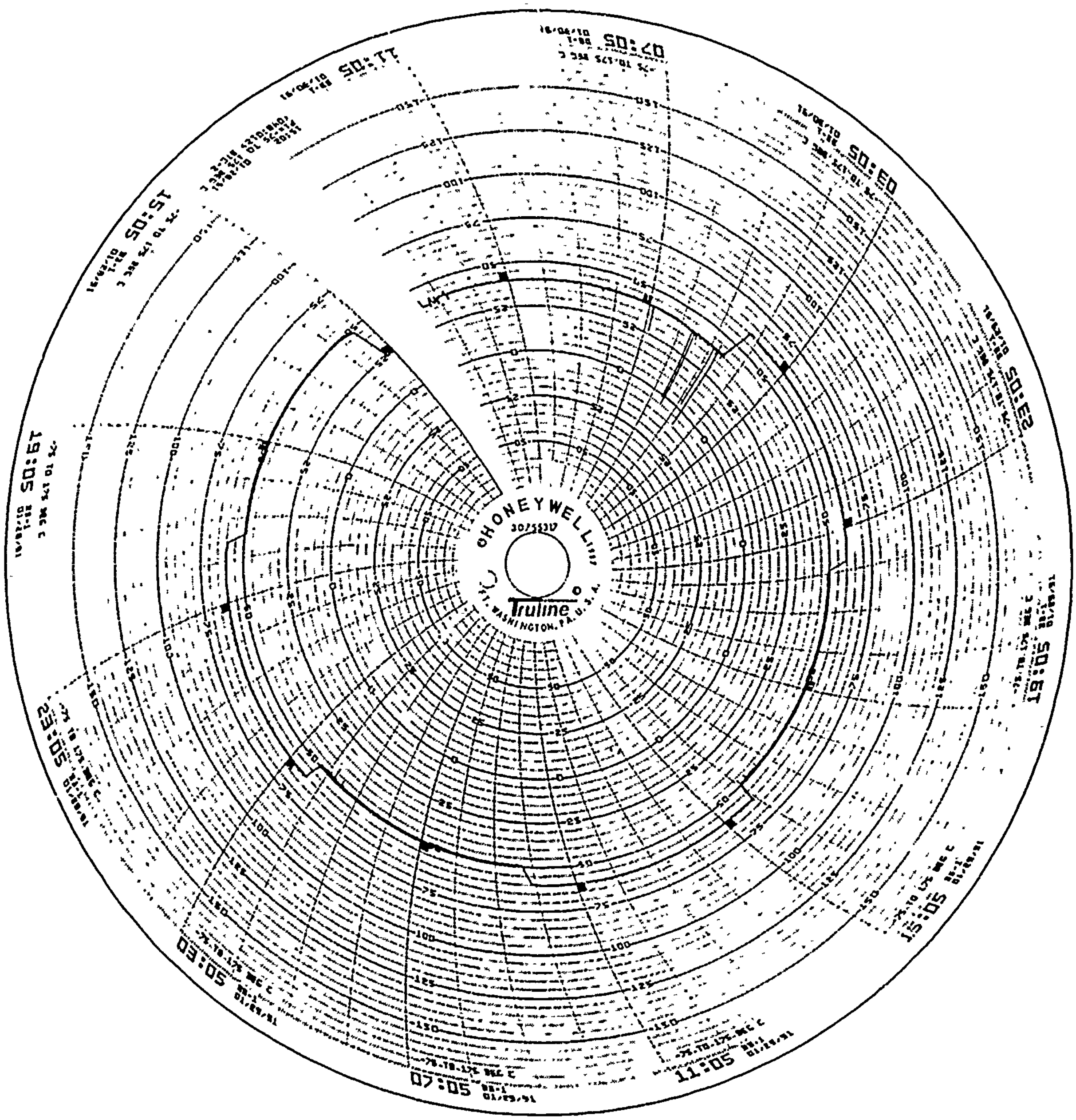

Figure 12. Original high-temperature profile for unit 3.

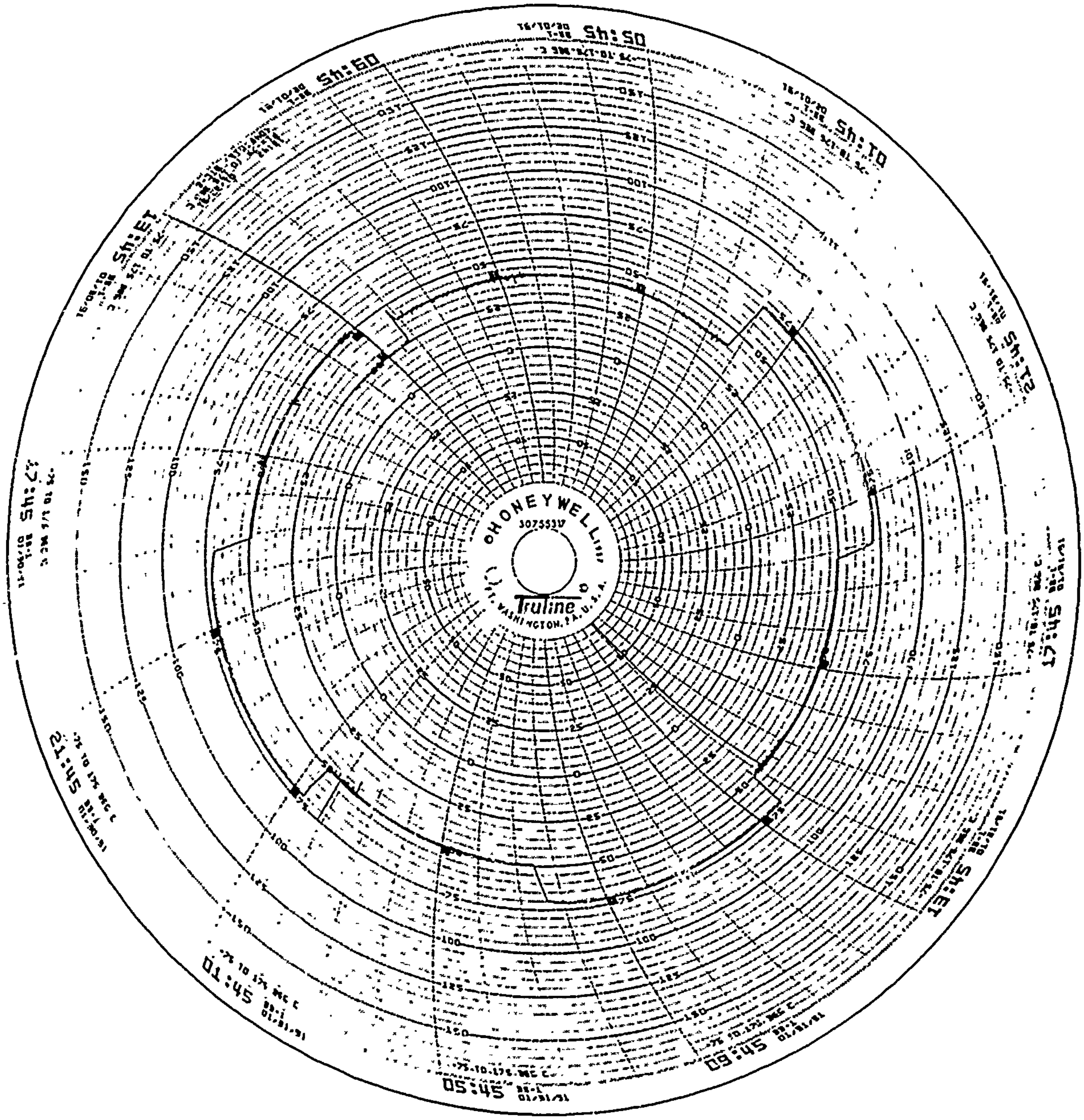

Figure 13. First part of second high-temperature profile for unit 3.

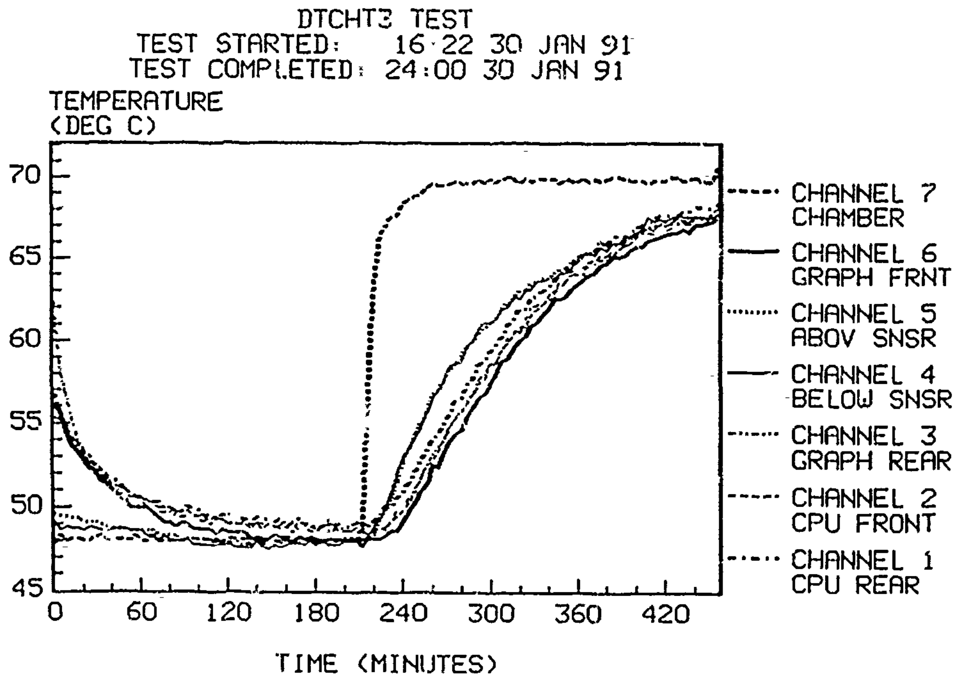

Figure 14. High-temperature data from unit 3 storage test.

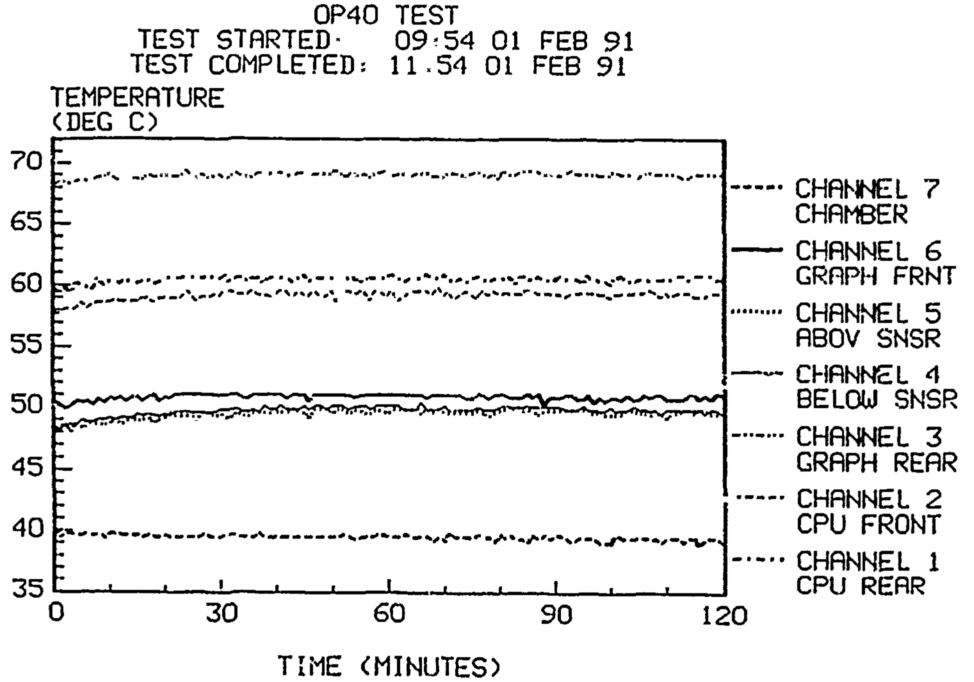

Figure 15. High-temperature operation data for unit 3.

2.4 LOW-TEMPERATURE TEST

Test Procedures. Units 1 and 3 were subjected to low-temperature testing as specified in MIL-STD-810D, Method 502.2, Procedures 1 and 2. Unit 1 was tested first, exposed to –40°C for 21.5 hours, then warmed to 0°C for one hour. The unit failed to boot after this exposure and subsequent warming to 22°C. The monitor was determined to be the problem. Unit 3 was exposed to –40°C for 15 hours and then warmed to 0°C for 6 hours. Unit 3 also failed to boot after this exposure and the monitor was again found to be faulty. The monitor was replaced and unit 3 still would not boot, reporting that the hard disk had failed to spin up. It booted successfully the following day; the hard disk had become functional without intervention. Figure 16 shows the temperature history of the final part of high-temperature testing on unit 3 and the low-temperature testing of the same unit.

To provide some minimal degree of confidence in the low-temperature capability of the DTC-II, unit 3 was exposed to successively lower temperatures beginning with –20°C and proceeding down in 10° increments. The system survived 19 hours of exposure to –20°C followed by a 7-hour warmup to 0°C before being powered up and operated. Unit 3 was next exposed to –30°C for 4 hours, and then exposed to 0°C for 4 hours, after which it failed to boot. The monitor was still functional but the hard disk had failed again. Unit 3 eventually booted after several days at room temperature. Figure 17 shows the temperature history of this second low-temperature test of unit 3.

Results. The DTC-II seems capable of withstanding exposure to –20°C without problems, but exposure to lower temperatures can destroy the monitor and cause the hard disk to exhibit erratic behavior. However, because the hard disk in unit 1 did not experience the erratic operation exhibited by the unit 3 disk, this may be an isolated problem. Further investigation of this behavior uld be undertaken by using several disk drives to determine whether or not the problem is a common one. As the disk in question is presently functioning properly, failure analysis is not currently feasible.

2.5 HUMIDITY TEST

Test Procedures. Unit 2 was subjected to the MIL-STD-810D, Method 507.2, Procedure III aggravated-humidity testing. Figure 18 shows the temperature and humidity profile used in this test. Unit 3 was subjected to the MIL-STD-810D, Method 507.2, Procedure II induced-humidity testing. The cycle used was hot-humid (cycle 4). Figure 19 shows the temperature and humidity profile used in this test. The scheduled duration of unit 2 testing was 10 days and the duration of unit 3 testing was 15 days. The aggravated-humidity test used on unit 2 makes no attempt to prevent condensation on the test item and is more severe than conditions found in nature. The test is used to reduce the time and cost of testing. The induced test used on unit 3 also makes no deliberate attempt to control condensation, but the temperature and humidity profile used makes condensation less likely to occur.

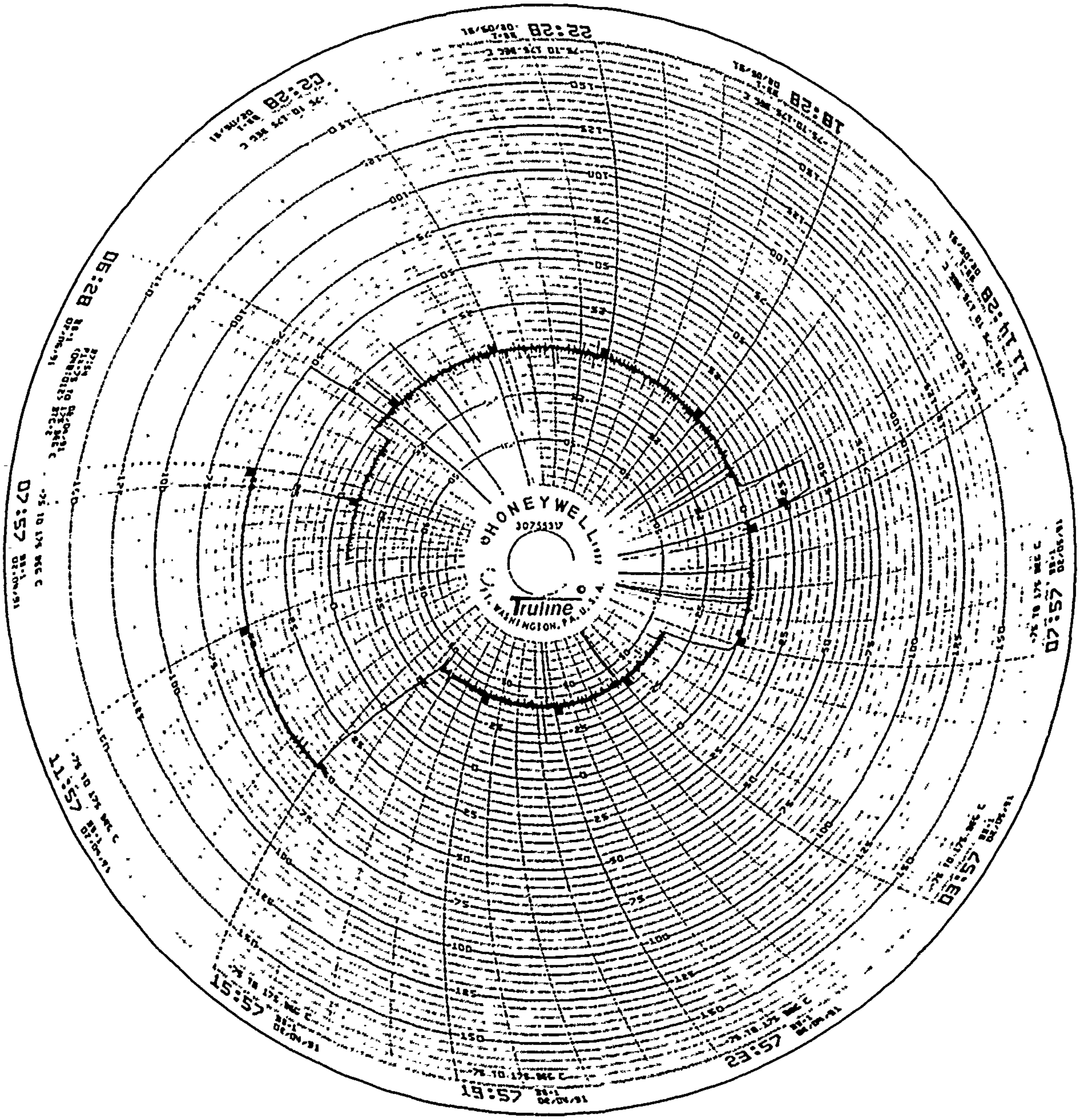

Figure 16. The final part of the high-temperature and low-temperature profiles for unit 3.

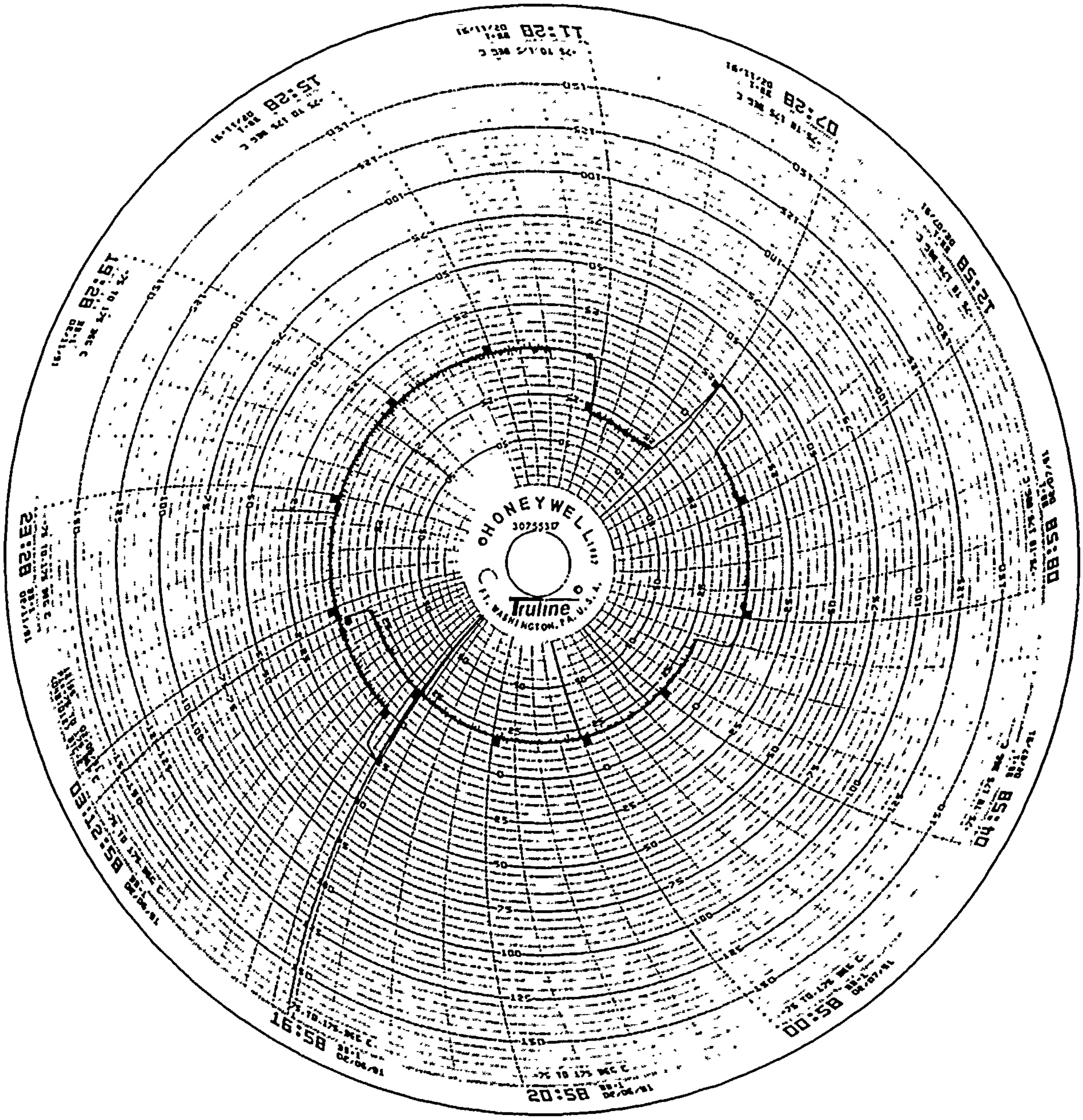

Figure 17. The second low-temperature profile for unit 3.

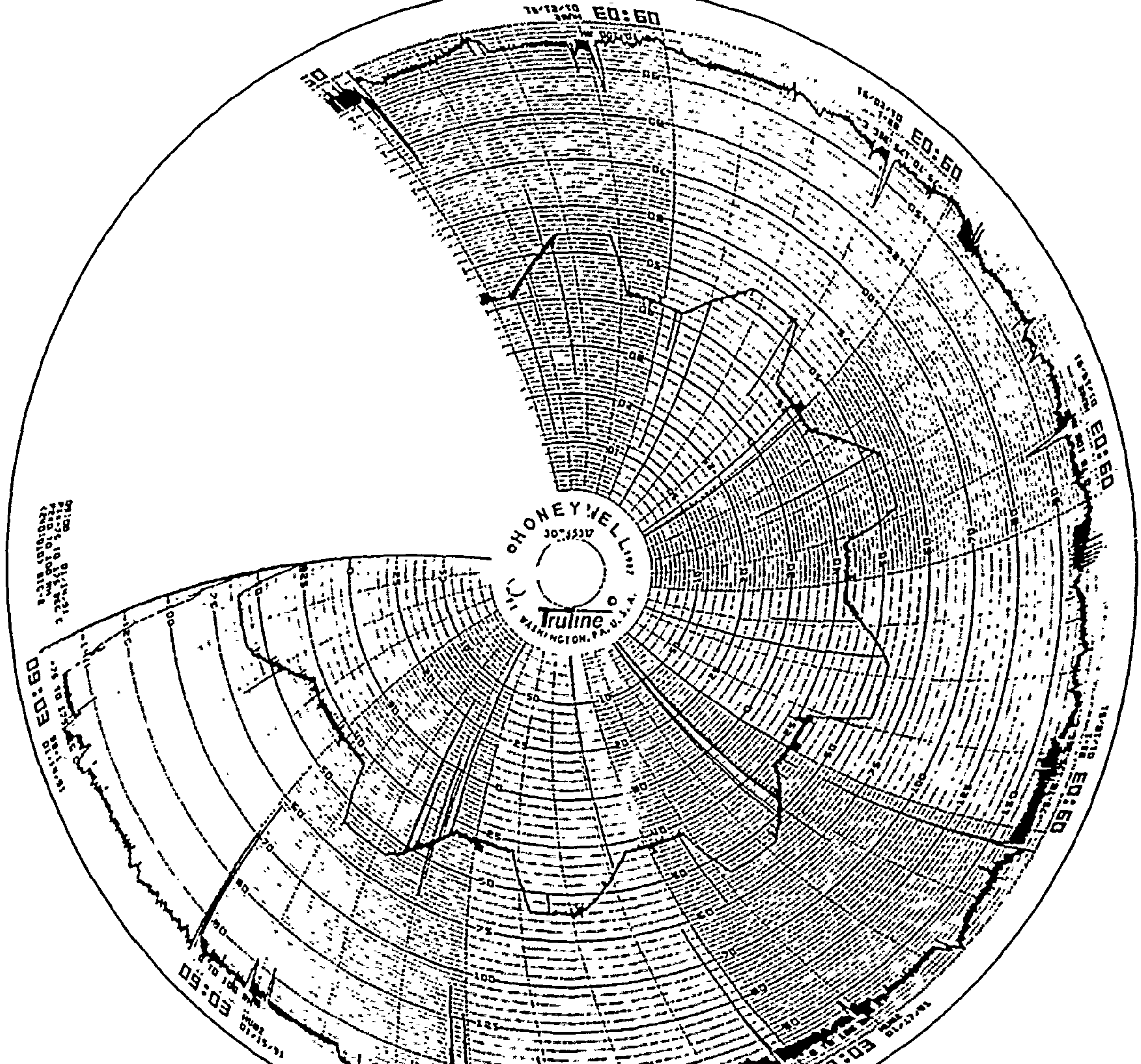

Figure 18. Aggravated-humidity profile for unit 2.

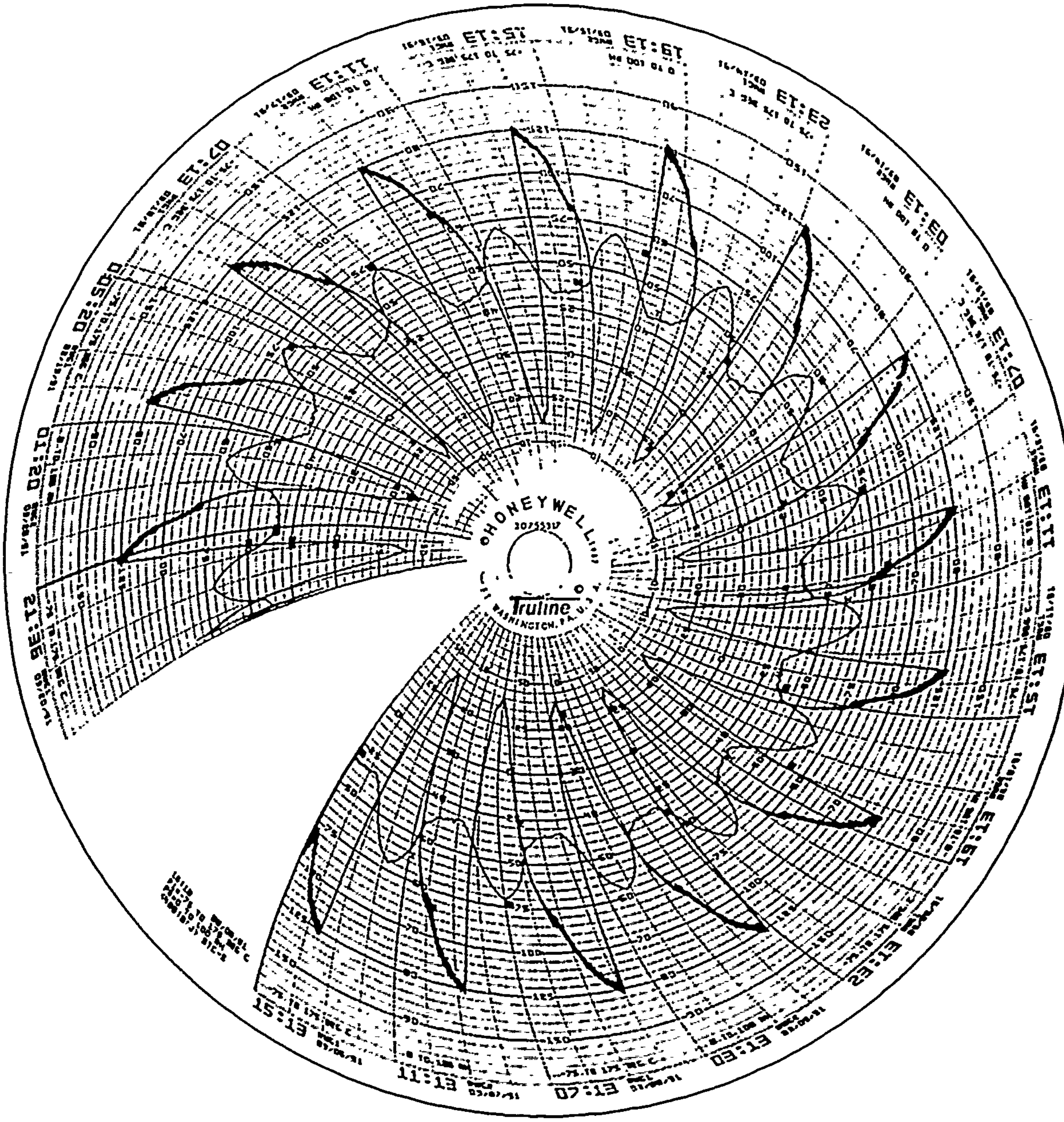

Figure 19. Induced-humidity profile for unit 3.

Results. After 8 days of aggravated-humidity cycling, unit 2 failed to boot. The unit was inspected and found to have extensive damage from corrosion. Typical damage is shown in figures 20 through 22. Figure 20 shows the cartridge tape unit, figure 21 shows the CPU drawer with the cartridge tape and the optical disk removed, and figure 22 is a closeup of one of the circuit boards.

Unit 3 survived the 15-day, hot-humid cycle shown in figure 19 without apparent problems.

2.6 ALTITUDE TEST

Test Procedures. Unit 3 was subjected to the altitude condition described in MIL-E-16400H(NAVY) paragraph 3.13.2. This paragraph calls for no degradation in performance following exposure to an altitude of 40,000 feet for a period of 8 hours. Figure 23 shows the chamber-pressure history for this test.

Results. There was no change in the performance of the system following the altitude test.

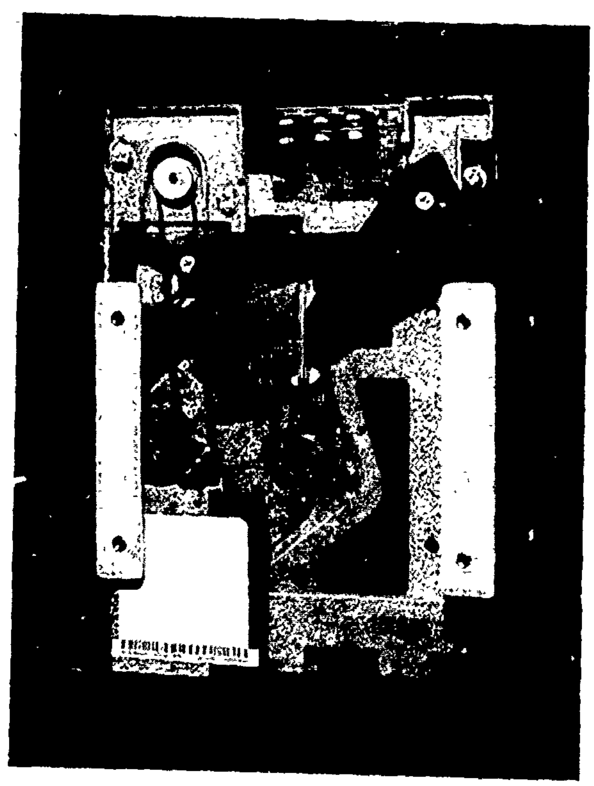

Figure 20. Corrosion damage to the cartridge tape drive.

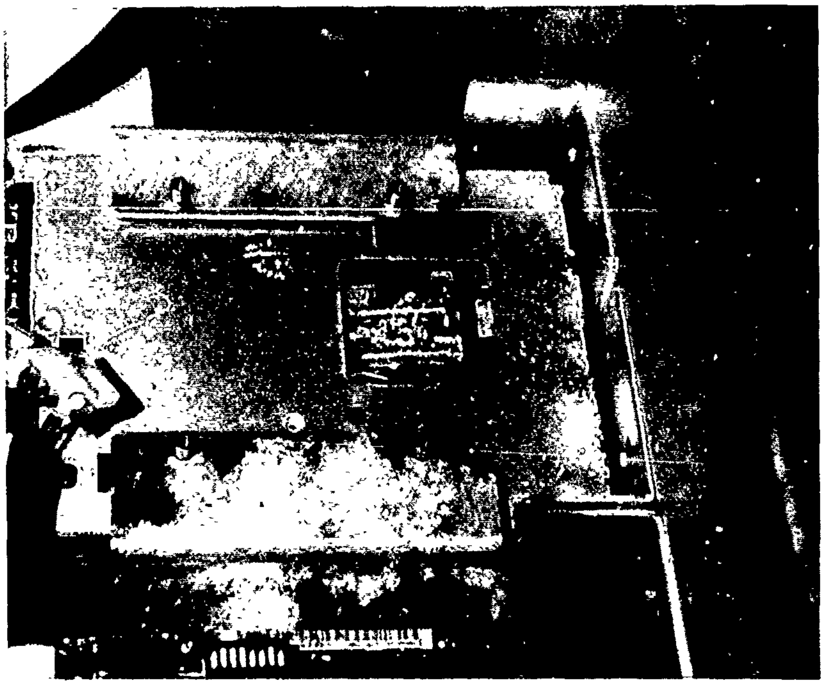

Figure 21. Corrosion damage following the aggravated-humidity test.

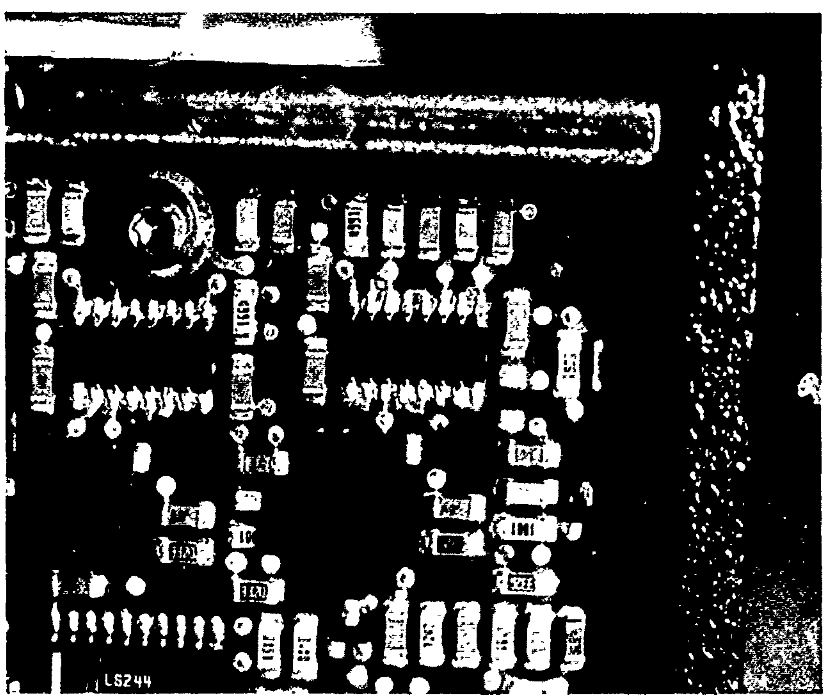

Figure 22. Corrosion damage on the circuit board.

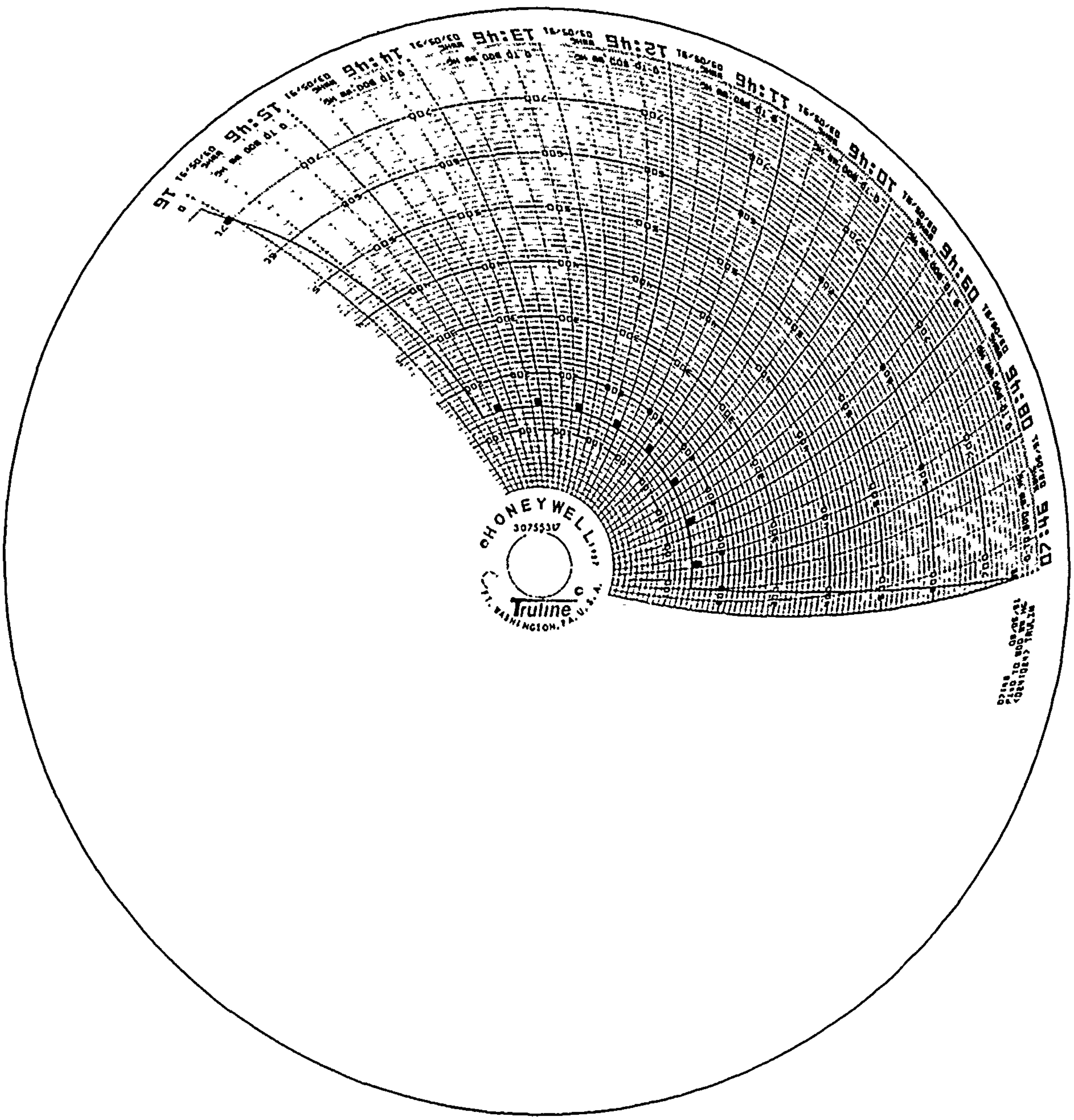

Figure 23. Altitude-test profile for unit 3.

2.7 INCLINATION TEST

Test Procedures. Units 1 and 2 were subjected to MIL-E-16400 dynamic-inclination testing consisting of 5 to 9 cycles per minute of 35° inclination from vertical. Each unit was tested twice in the fore-and-aft axis and twice in the side-to-side axis for 30 minutes. During the first test, the units were operational. During the second test, the units were powered down and all drawer slides were fully extended.

Results. No adverse effect resulted to either system during or following the inclination test.

2.8 SALT-FOG TEST

Test Procedures. Material samples, including the printer rails, two eyebolts, and the transceiver brackets, were removed from unit 1 and subjected to MIL-STD-810D, Method 509.2, salt-fog testing for a period of 48 hours.

Results. No unusual corrosion was apparent on the test samples. Results are shown on figures 24 and 25.

3.0 ELECTRICAL TESTS AND RESULTS

3.1 POWER AND POWER-FACTOR TEST

True power measured between 920 and 940 watts. The power variation appeared related to the operational status of the DTC-II at any given time. Power factor measured 0.80 (assumed lagging).

3.2 VOLTAGE-TRANSIENT TEST (±10%)

No change in operation was noted during this test.

3.3 FREQUENCY-TRANSIENT TEST (±5%)

No change in operation was noted during this test.

3.4 POWER-INTERRUPT TEST (60 msec; 2 min)

The equipment continued operation with no apparent change except for the power failure alarm, which was reset.

Figure 24. Salt-fog result—eyebolt closeup.

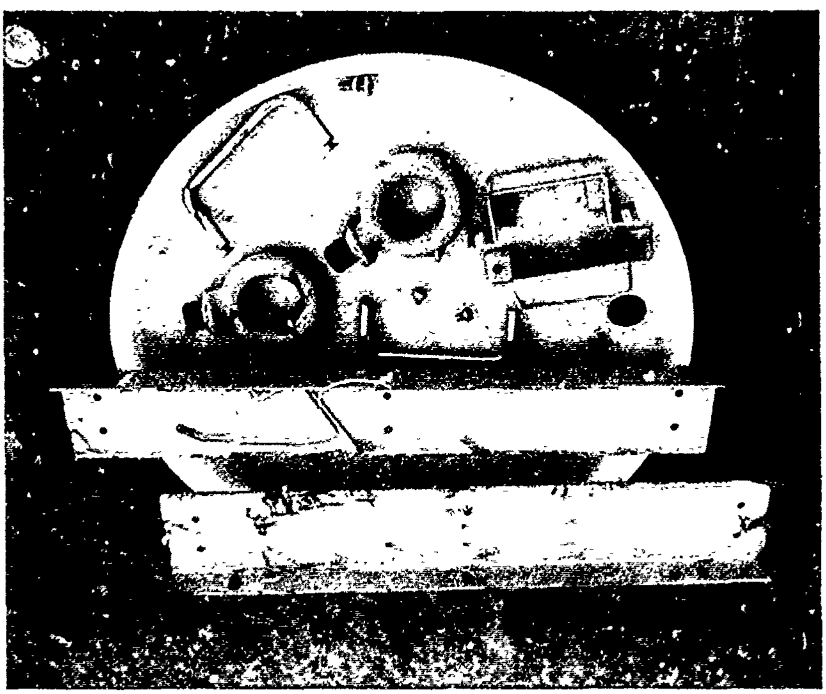

Figure 25. Salt-fog result—larger view.

3.5 LEAKAGE-CURRENT TEST

Leakage current measured 45 mV with normal line polarity and 130 mV with reversed line polarity, both well below the 7.5V allowed.

3.6 TRANSIENT-VOLTAGE AND FREQUENCY TEST

This is a ±20-percent and ±5-percent frequency within a 2-second test. The equipment continued operation with no observed change during the test.

3.7 SPIKE-VOLTAGE TEST (2500 V)

The 2500-V spike was applied in series with the normal line voltage, from line to neutral, and from line to ground. In each configuration, the spike was applied at the peak of the positive going 60 Hz waveform and at the crossing of the axis of the 60 Hz waveform. In all cases, the 2500 V was a positive going pulse. No change in operation was observed in any of the tests.

4.0 ELECTROMAGNETIC-COMPATIBILITY (EMC) TESTING OF THE TFCC-DTC

4.1 DESCRIPTION OF THE TEST ITEM

A Desk-Top Tactical Support Computer, DTC-II, S/N 199, was used for the EMC tests.

4.2 TEST SEQUENCE

The following test sequence was performed: (1) MIL-STD-461C, conducted and radiated emissions, and (2) MIL-STD-462, radiated susceptibility. EMC tests were performed to measure the performance of the DTC-II equipment in meeting the requirements of MIL-STD-461C, by using the techniques described in MIL-STD-42. Conducted emission tests were: CE-01 and CE-03. Radiated emission tests were RE-02. Radiated susceptibility tests were RS-03.

5.0 ELECTROMAGNETIC COMPATIBILITY (EMC) TESTS

5.1 CONDUCTED EMISSIONS TESTS

Test CE-01 Procedures. Narrowband emissions from 30 Hz to 15 kHz were measured on each powerline. A Fairchild PCL-10 current probe was used as the pickup device with a HP-8568B spectrum analyzer as the selective voltmeter. Figures 26 and 27 show the results of this test. The data shown were well within the limits that were adjusted for the 10-amp load current.

Results. The data were satisfactory.

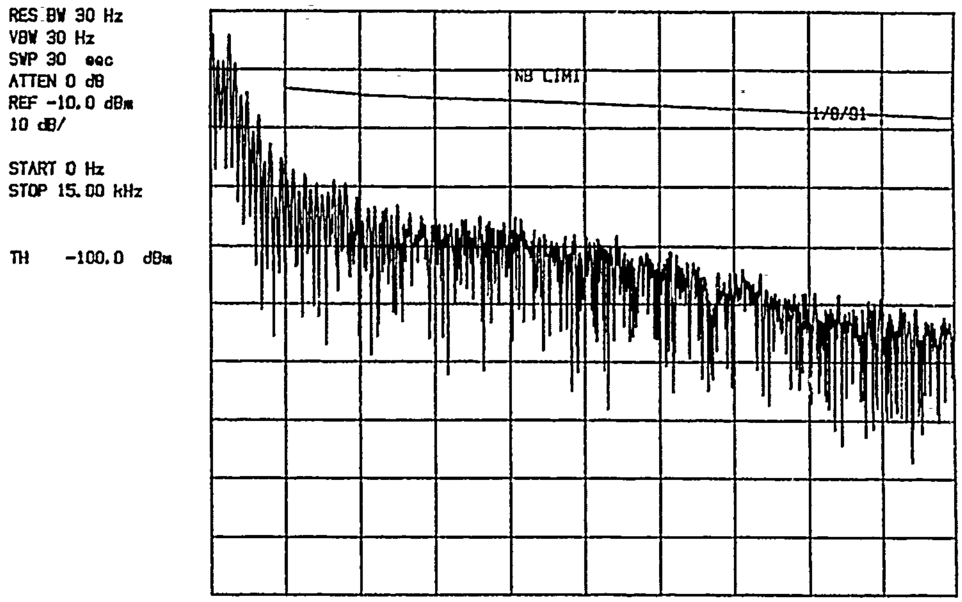

Figure 26. MIL-STD-462 CE-01 narrowband emissions, 30 Hz to 15 kHz Desk-Top Tactical Support Computer, DTC-II, current probe: Fairchild PCL-10, line side.

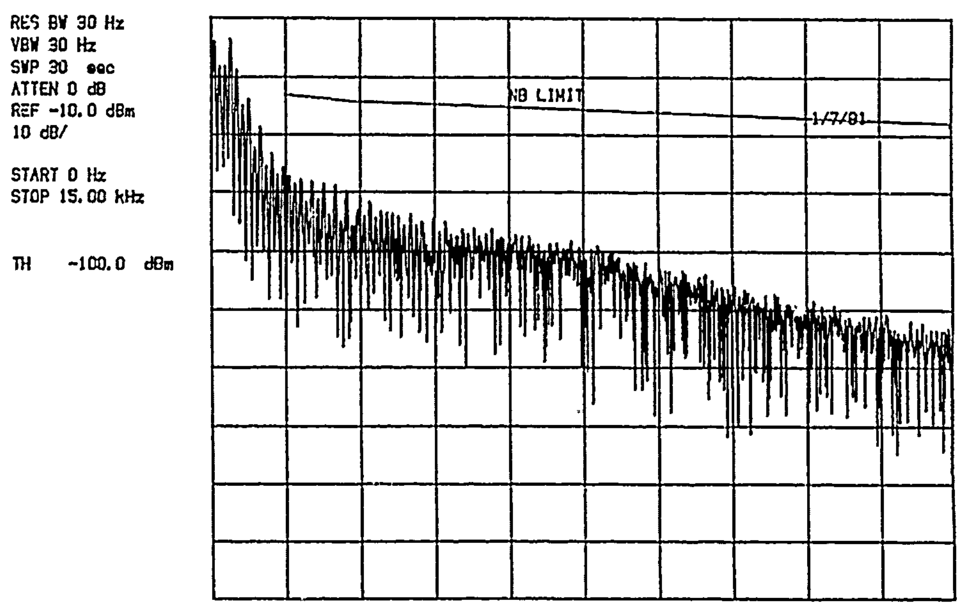

Figure 27. MIL-STD-462 CE-01 narrowband emissions, 30 Hz to 15 kHz Desk-Top Tactical Support Computer, DTC-II, current probe: Fairchild PCL-10, neutral side.

Test CE-03 Procedures. Broadband and narrowband emissions from 15 kHz to 50 MHz were measured on each power lead. The current probe was a Stoddart 91550-1 with an HP-8568B spectrum analyzer as the selective voltmeter. Figures 28 and 29 show the results. Analysis of the data shows the power-lead emissions are both broadband and narrowband. These data exceed both limits by approximately 10 dB. The addition of a powerline filter in the equipment at the power connector might be considered.

Results. The data exceed limits by approximately 10 dB. Additional or alternate power-lead filtering is recommended.

5.2 RADIATED-EMISSIONS TESTS

Test RE-02 Procedures. Electric-field emissions were measured over the frequency range of 14 kHz to 10 GHz. Measurements were made with the equipment in the full operating mode.

A Singer 95010-1 50-inch top-loaded active rod antenna was used from 14 kHz to 40 MHz. From 40 to 200 MHz, a Singer 94455-1 biconical antenna was used. Measurements were made with the biconical antenna oriented both vertically and horizontally. In the range of 200 to 1000 MHz, a Fairchild LCA-25 log conical was used. The frequency range of 1 to 10 GHz was covered with a series of horn antennas: the Singer EMC 1010, 1020, 1030, and 1040.

The selective voltmeter from 14 kHz to 1.5 GHz was a HP-8568A and from 1.5 GHz to 10 GHz, a Tektronix 492. Figures 30 through 33 show the RE-02 measurements. No emissions were observed in the frequency range of 1 to 10 GHz. By using a loop probe, we determined that some of the emissions in the frequency range below 1 GHz were radiating from the tape drive just above the keyboard. This drive has no front cover. RF emissions from this drive would probably be reduced by the addition of a front cover.

Results. Emissions exceeding limits by approximately 15 to 20 dB were observed in the frequency range of 35 to 200 MHz. By using a loop probe, we determined that the emissions were radiating from the uncovered tape drive front. Reduction of emissions by circuit modification to reduce interference generation, change of cabinet design to increase EMI suppression, and installation of interconnecting cabling that has increased shielding effectiveness are all recommended.

5.3 RADIATED-SUSCEPTIBILITY TEST

Test RS-03 Procedures. Susceptibility to radiated electric fields was investigated in the frequency range of 14 kHz to 1 GHz. This test was conducted by subjecting the DTC-II equipment to an electric field of 10 volts per meter. The radiating antennas were located 1 meter from the equipment.

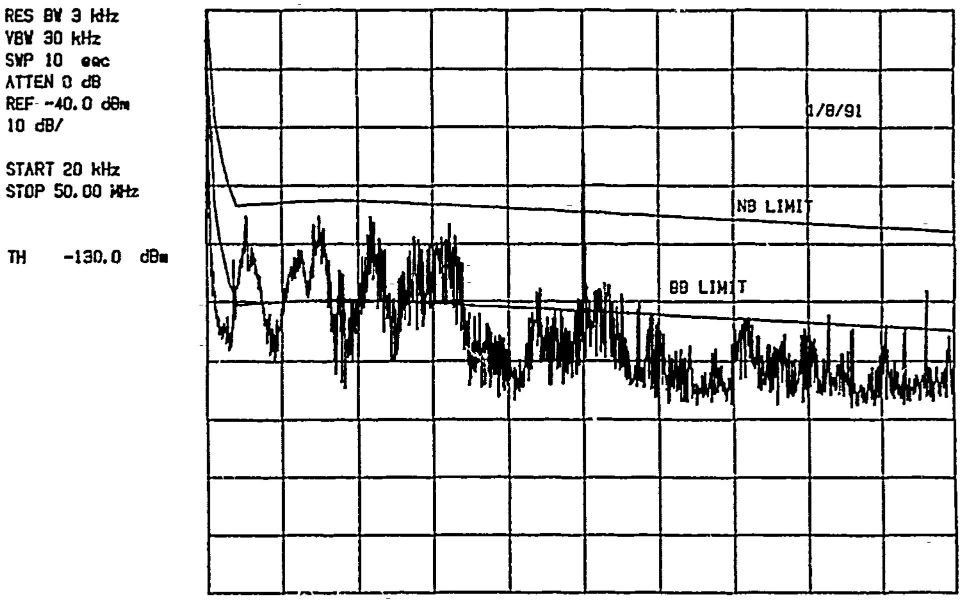

Figure 28. MIL-STD-462 CE-03 emissions, Desk-Top Tactical Support Computer, DTC-II, current probe: Stoddart 91550-1, line side.

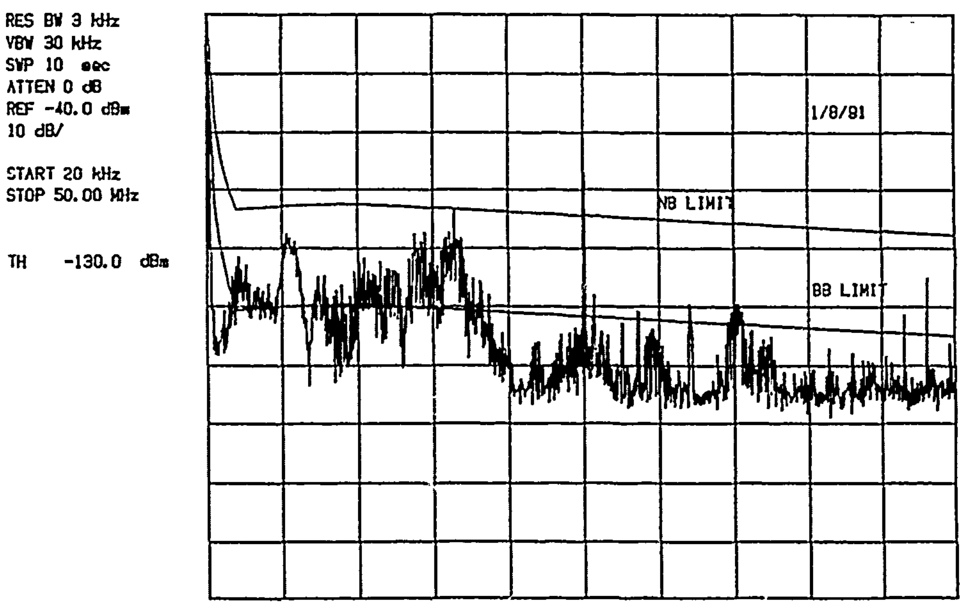

Figure 29. MIL-STD-462 CE-03 emissions, Desk-Top Tactical Support Computer, DTC-II, current probe: Stoddart 91550-1, neutral side.

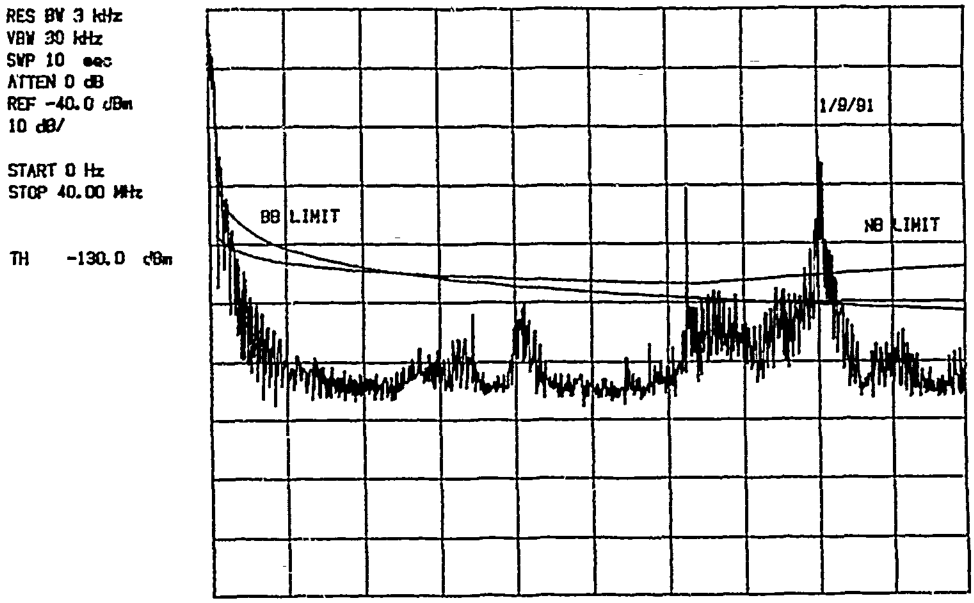

Figure 30. MIL-STD-462 RE-02 emissions, Desk-Top Tactical Support Computer, DTC-II, Singer 95010-1 50-inch top-loaded antenna.

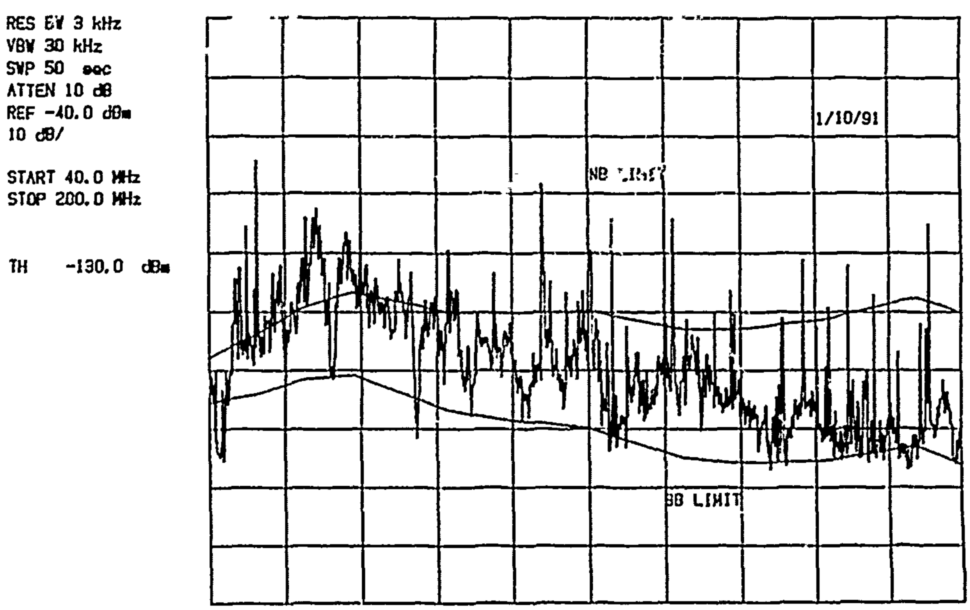

Figure 31. MIL-STD-462 RE-02 emissions, Desk-Top Tactical Support Computer, DTC-II, Singer 94455-1 biconical antenna, vertical polarization.

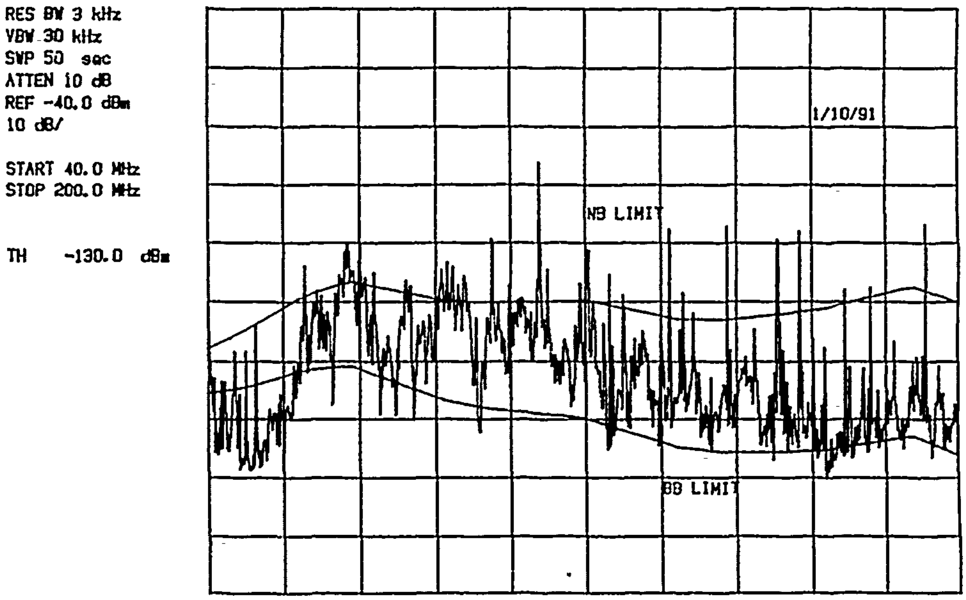

Figure 32. MIL-STD-462 RE-02 emissions, Desk-Top Tactical Support Computer, DTC-II, Singer 94455-1 biconical antenna, horizontal polarization.

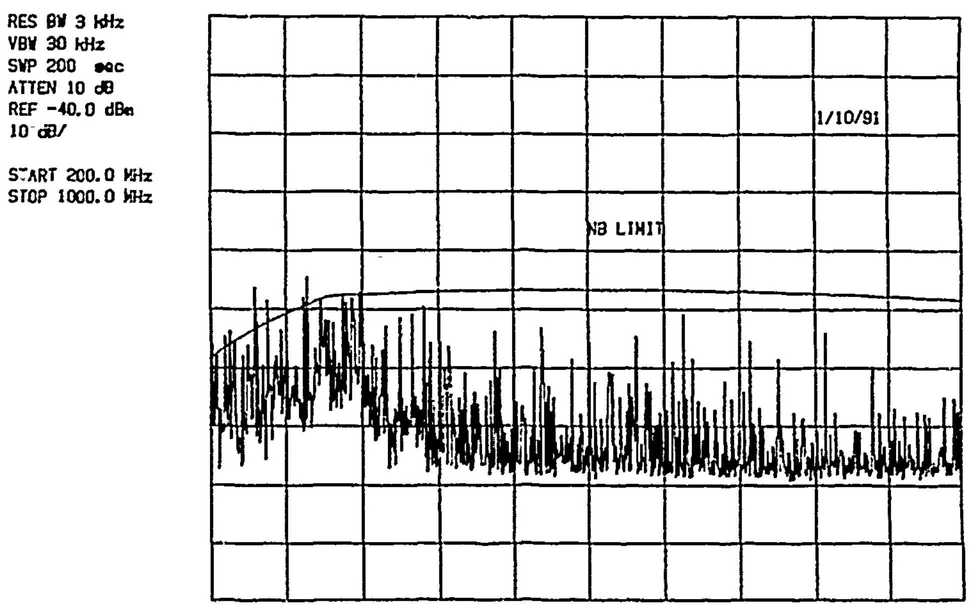

Figure 33. MIL-STD-462 RE-02 emissions, Desk-Top Tactical Support Computer, DTC-II, Fairchild LCA-25 log conical antenna.

The radiating antenna for the frequency range of 14 kHz to 30 MHz was an EMCO parallel-element antenna, Model 3107. The signal source from 14 kHz to 165 kHz was an RF Power Labs, Inc., Model M125L driven by an HP 204D test oscillator. In the range of 165 kHz to 30 MHz, the source was an RF Power Labs, Inc., Model M125L power amplifier driven by an HP Model 606B signal generator.

From 30 to 200 MHz, an EMCO high-field biconical antenna Model 3109 was used. The excitation from 30 MHz to 50 MHz was the same HP606B signal generator driving the Model M125L. From 50 to 200 MHz, the transmit source was an Ailtech Model 445A Power Oscillator with a Model 185-1-2 plug-in unit.

A Stoddart Model 91597-2 bow tie was used as the radiating antenna from 200 to 1000 MHz. The signal source was an Ailtech Model 445A power oscillator with models 186-1-2 and 187-1-2 plug-in units. The only susceptibility observed was a slight wavy motion on the monitor screen at generator frequencies of 270 MHz, 340 MHz, and 580 MHz. No other equipment functions were affected.

Results. Susceptibility test RS-03 was performed with no observed adverse effects on the equipment operation other than a slight wavy motion of the monitor presentation when the equipment was exposed to RF energy at frequencies of 270 MHz, 340 MHz, and 580 MHz. Other functions of the DTC-II appeared to be normal and unaffected.

6.0 REFERENCES

Military Standard

MIL-STD-167-1(SHIPS). 1 May 1974. Mechanical Vibrations of Shipboard Equipment (Type I—Environmental and Type II—Internally Excited)

MIL-STD-210C. 9 January 1987. Climatic Information to Determine Design and Test Requirements for Military Systems and Equipment.

MIL-STD-461C. 4 August 1986. Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference.

MIL-STD-462. 4 August 1986. Electromagnetic Interference Characteristics, Measurement of.

MIL-STD-810D. 14 July 1989. Environmental Test Methods and Engineering Guidelines.

MIL-STD-1399 (NAVY), Section 300A. 13 October 1987. Interface Standard for Shipboard Systems Electric Power, Alternating Current (Metric).

Military Specification

MIL-E-16400H(NAVY). 13 July 1987. Electronic, Interior Communication and Navigation Equipment, Naval Ship and Shore, General Specification for.

MIL-S-901D(NAVY). 17 March 1989. Shock Tests, High-Impact Shipboard Machinery, Equipment, and Systems, Requirements for.

APPENDIX A

RACK MONITOR FAILURE REPORT

December 17, 1990

TO: BOB DALLEZOTTE C3

FM: GARY LOES SONY GRAPHIC DISPLAY

RE: RACK MONITOR FAILURE REPORT

S/N 2048368 (DUAL RACK, LOWER)

Symptom: No high voltage. Power on indicator was operational.

Transistor Q215 (horizontal output) on the deflection board had a broken lead as a direct result of vibration testing. This transistor is mounted to a large heat sink that flexed with respect to the PC board during vibration testing. This caused the center lead of the transistor to weaken and break.

S/N 2047554 (DUAL RACK, UPPER)

Symptom: No high voltage and no power on indicator.

Transistor Q215 on the deflection board had a broken lead as a direct result of vibration testing. (See report of S/N 2048368 above.) The case of transistor Q4 on the power supply board cracked as a direct result of vibration testing. This transistor is also attached to a heat sink that could vibrate with respect to the PC board. The leads of the transistor remained fixed on the PC board and the case cracked. Also, the solder joint of capacitor C57 on the power supply board failed resulting in a poor connection with the PC board.

S/N 2051100

Symptom: No high voltage. Horizontal convergence failed just before the monitor shut down.

Transistor Q215 (horizontal output) on the deflection board shorted and caused fuse PS201 to open.

The LA board (convergence waveform) failed with the loss of the horizontal pulse to the horizontal convergence output circuit. (Q12 on the LA board is suspected to have failed.) Op amp IC3 failed (smoked) during test of the convergence board. This device may or may not have failed during the environmental tests.

The exact cause of the failures on this unit is unknown. However, it is suspected that condensation was the cause.

epe
EPE TECHNOLOGIES INC

January 30, 1991

Vijay K. Aggarwal
C-3, Inc.
460 Herndon Parkway
Herndon, VA 22070-5201

re: Vibration Test Failures

Dear Vijay:

We have received the two rack units from the San Diego testing facility. It is our understanding that these units operated satisfactorily through the majority of the shock and vibration tests. We further understand that the units subsequently failed when subjected to continuous vibration at the resonant frequency.

Upon examination of the units, they were found to be mechanically intact with no damage or structural deformation . In diagnosing the failures, it was determined that one unit had a blown fuse in the auxiliary power supply and the other unit had a resistor that was overloaded.

Our conclusions are the same for both units. When the units are operated with sustained vibration at resonant frequencies, the dynamic displacement (flexing) of the main printed circuit board and the chassis under pan will be magnified. At sufficient amplitude, this would result in contact of the two surfaces. With the electrical neutral bonded to the chassis ground, this mechanical contact will result in an electrical short circuit. The part of the printed circuit board that makes contact will determine which circuit on the board is shorted.

From the testing previously performed by C-3 and EPE, these units have performed extremely well under most adverse conditions. However, we are taking steps to change future production to eliminate the possibility of electrical contact between the printed circuit boards and the chassis. This will be accomplished through the addition of an insulating barrier and through vibration absorption mounting of the boards. When this design change is finalized, I will be contacting you for approval of the ECN.

Best regards,

P. D. Madden, P.E.
V.P. Engineering

PDM:ejb
cc: T. Hunter, B. Patel, B. Roberts, K. Ruck, D. Zach
B. Medlin - The Lee Agency

APPENDIX B

ENVIRONMENTAL TEST PROCEDURE FOR THE TFCC–DTC–II

1.0 INTRODUCTION

This document presents the procedure for a test program for the TFCC—DTC-II program.

1.1 PURPOSE

The recommended approach to qualification and test requirements are presented in this document.

1.2 OBJECTIVE

The objective of this test procedure is to demonstrate the capability of the DTC-II to meet the PMW-162 testing and certification program environmental requirements.

1.3 SCOPE

The test procedure consists of a series of electronic measurement and unit operational tests that will ensure compliance with the environmental and electronic requirements specified in section 4 of this document.

1.4 DESCRIPTION OF TEST ARTICLES

TFCC Increment II, II+, and III workstation requirements are being addressed with respect to installation of the Navy Standard DTC-II on shipboard platforms. This evolving program includes design analysis of the standard DTC-II single- and dual-screen configuration (figure B-1), preparation of the environmental test plan, test procedure and testing, with the option of including design modifications of the DTC-II rack by C3 as a result of the testing. Naval Ocean Systems Center will prepare a final test report that will support the submission of any required waiver requests to the respective NAVSEA PARM or SLM.

1.5 TEST SCHEDULE

Testing is planned for FY 91. Two assemblies shall be tested. One will be a single-monitor configuration; the other will be the dual-monitor configuration. The following tests will be used:

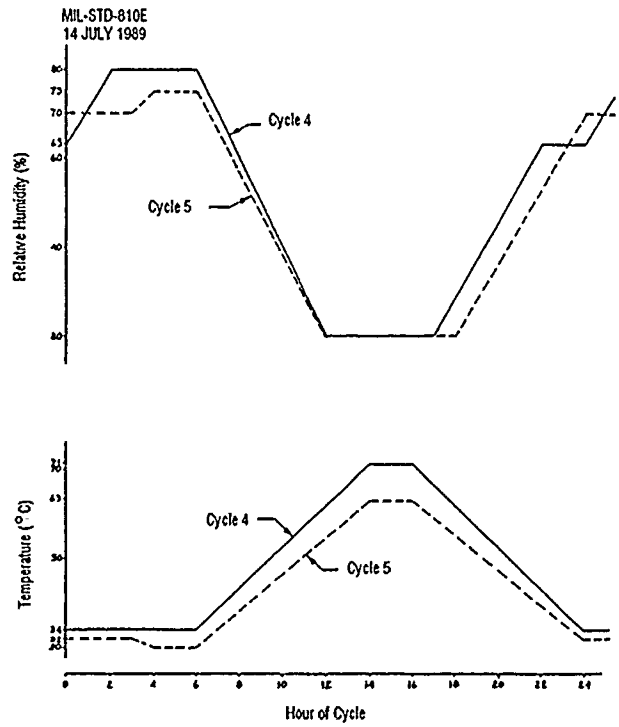

Figure B-1. Induced temperature-humidity cycles.

MIL-S-901D	Shock Tests, High Impact, Shipboard Machinery, Equipment and Systems, Requirements for.
MIL-E-16400H	Electronic, Interior Communication, and Navigation Equipment, Naval Ship and Shore, General Specification for.
MIL-STD-167-1	Mechanical Vibrations of Shipboard Equipment.
MIL-STD-461B	Electromagnetic Emission and Susceptibility, Requirements for.
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of.
MIL-STD-810D	Environmental Test Methods and Engineering Guidelines.
MIL-STD-1399 (NAVY) Section 300A	Interface Standard for Shipboard Systems Electric Power, Alternating Current (Metric).
OSHA 1910.003 to 1910.0017	

2.0 QUALIFICATION TEST REQUIREMENTS

MIL-STD-1399 and MIL-E-16400 will be of basic concern to test personnel. These documents set the criteria to determine satisfactory operation of the units under test. Except as otherwise specified herein, the general test conditions shall be in accordance with general requirements of MIL-STD-810.

NOTE: Standard Ambient Conditions. Maintain temperature at 23° ± 10°C (73° ± 18°F), 50 ± 30 percent relative humidity, and 725; +50, −75 mm (28.5; +2.0, −3.0 inches) of mercury atmostpheric pressure.

2.1 PRETEST PERFORMANCE RECORD

Before testing, the DTC-II shall be operated at standard ambient conditions to obtain and record data determining compliance with the performance parameters and the safety requirements of the equipment specification. Data selected from these baseline measurements will be monitored during the various environmental exposures for indication of malfunction or degradation. At the completion of all the environmental tests, selected measurements taken for the baseline shall be repeated.

2.1.1 Pretest Record.

The pretest record shall include the functional parameters to be monitored before, during, and after the test, if not specified in the equipment specification. This shall include acceptable functional limits (with permissible degradation) when operation of the DTC-II is required.

2.2 INSTALLATION OF DTC-II IN TEST FACILITY

Unless otherwise specified, the DTC-II shall be installed in the test facility in a manner that simulates service usage, making connections and attaching instrumentation as necessary. Plugs, covers, and inspection plates not used in servicing shall remain in place. When mechanical or electrical connections are not used, the connections normally protected in service shall be adequately covered. For tests where temperature values are controlled, the test chamber shall be at standard ambient conditions during the installation of the DTC-II. The DTC-II shall then be operated to determine that no malfunction or damage was caused due to faulty installation or handling of the DTC-II in the test facility.

2.3 PERFORMANCE CHECK DURING TEST

When operation of the DTC-II is required during the test exposure, suitable tests shall be performed to determine whether the test exposure is producing changes in performance when compared with pretest data.

2.4 POST-TEST DATA

At the completion of each environmental test, the DTC-II shall be inspected in accordance with the equipment specification and the results shall be compared with the pretest data.

2.5 TEST DATA

Test data shall include complete identification of all DTC-IIs and accessories. The data shall include the actual test sequence used and ambient test conditions recorded periodically during the test period. The test record shall contain a signature and data block for certification for the test data by the test engineer.

2.6 FAILURE CRITERIA

The unit under test shall have failed a test when any of the following occur:

a. Monitored functional parameters or equipment operation exceed limits specified in the individual equipment specification. Where minimum acceptable performance is not specified, the performance after the test shall be the same as performance before the test.

b. Catastrophic or structural failure.

c. Distortion or displacement of mechanical parts that cause difficulty of servicing or replacing a part.

d. Any condition that results in a hazard to personnel or equipment safety.

e. Deterioration, corrosion, or change in performance limits causing failure to meet operational service or maintenance requirements.

f. Leakage or discoloration of impregnating compounds that would cause a decrease in service life or reliability.

2.6.1 Stopping Testing in case of Failure.

In case of failure, testing shall be stopped and shall not continue until approval is obtained from the test requester and test conductor. If the failure is a catastrophic failure, final acceptance will require repeating the test in which the failure occurred. It is also necessary to consider whether previous tests had contributed any stresses resulting in the failure. If the failure is minor, the test conductor must decide if it is necessary to repeat the test in question before accepting the results as final. Repeating the test is the preferable course to increase the confidence in the unit's acceptability.

2.6.2 Inspection of Failure by Code 433 representative.

In case of a failure, an onsite representative of NOSC Code 433 or the manufacturer may examine the unit under test. If the failure can be repaired within 24 hours, testing may continue after the repair upon approval as stated above. If it cannot be done within that time limitation, the test conductor and test requester mutually will agree on a time to restart.

2.6.3 Failure Report.

In case of a failure, a failure report shall be written and submitted to the test conductor and test requester. The report shall contain the following information:

a. Date and time of failure.

b. Identification of section of test in which failure occurred.

c. Identification of previous tests to which the unit under test has been subjected.

d. Description of failure.

e. Test engineer's comments and recommendations.

2.7 RECOMMENDED ORDER OF TESTS

It is recommended, but not mandatory, that qualification testing be conducted in the order as shown in the Table of Contents of this document. The intent of this qualification test is to derive as much information as possible about how each environment affects the DTC-II and to apply this information to the design and future procurement of DTC-II. The preferred order of tests will also promote a success oriented program.

3.0 QUALIFICATION TEST METHODS

3.1 LOW-TEMPERATURE TEST

Low-temperature testing is specified in MIL-E-16400, Method 502.2, Procedure 1, storage, and in MIL-STD-810, Procedure 2, operation. When nonoperating, the units will be subjected to not less than a 4-hour soak at -40°C and then stabilized and operated at 0°C The detailed procedure is:

Step 1 - Prepare and test the DTC-II in accordance with Section 3

Step 2 - Lower the internal chamber temperature to the storage temperature -40°C and maintain for a period of not less than 4 hours after stabilization.

Step 3 - Inspect the DTC-II in accordance with Section 3.

Step 4 - Adjust the internal chamber temperature to 0°C and maintain until temperature stabilization of the DTC-II is reached.

Step 5 - Operate the DTC-II until temperature stabilization is again achieved. The duration of steps 4 and 5 combined should not be less than 12 hours, at least 2 of which shall be in each of the stabilized conditions. Obtain results in accordance with Section 3.

Step 6 - Return the DTC-II, nonoperating, to standard ambient conditions and stabilize.

Step 7 - Operate and inspect the DTC-II and obtain results in accordance with Section 3.

NOTE: The rate of temperature change may be the maximum attainable by the chamber but shall not exceed 10°C (18°F) per minute.

3.2 HIGH-TEMPERATURE TEST

High-temperature testing is specified in Method 501.2, Procedure II of MIL-STD-810 except as modified by MIL-E-16400 and NAVSEA. When nonoperating, the units will be subjected to three 12-hour cycles between 49°C and 60°C, stabilized for 6 hours at 40°C, at which time the equipment shall be operated for not less that 2 hours before operating tests. If difficulties are encountered at the 40°C operational test, document the problem and restabilize for 6 hours at 32°C. After stabilizing, operate the equipment for not less than 2 hours and, once again, perform the operational test. If no difficulties are encountered at the 40°C stabilization, restabilize at 50°C. After stabilizing, operate the equipment for minimum of 2 hours and perform the operational test. The detailed procedure is as follows:

Step 1 - Prepare and test the DTC-II in accordance with Section 3.

Step 2 - Raise the internal chamber temperature to 49°C.

Step 3 - Raise the internal chamber temperature to 60°C in 12 hours.

Step 4 - Lower the internal chamber temperature to 49°C in 12 hours.

Step 5 - Repeat steps 3 and 4 for a total of 3 cycles.

Step 6 - Adjust the internal chamber temperature to 40°C and maintain for 6 hours for temperature stabilization.

Step 7 - Operate the DTC-II for more than 2 hours at 40°C and obtain results in accordance with Section 3.

Step 8 - If difficulties are encountered at 40°C in step 7, repeat steps 6 and 7 at 32°C.

Step 9 - If no difficulties are encountered at 40°C in step 7, repeat steps 6 and 7 at 50°C.

Step 10 - Return the DTC-II, nonoperating, to standard ambient conditions and stabilize.

Step 11 - Operate the DTC-II for a period of at least 2 hours in the stabilized condition.

Step 12 - Operate and inspect the DTC-II and obtain results in accordance with Section 3.

NOTE: The rate of temperature change may be the maximum attainable by the chamber, but shall not exceed 10°C (18°F) per minute.

3.3 LOW-PRESSURE (ALTITUDE) TEST

Once de-energized, the DTC-II unit shall be subjected to reduced atmospheric pressure corresponding to an altitude of not less than 40,000 feet for not less than 8 hours as specified in MIL-E-16400. An operating test shall be performed on the unit after it has been returned to standard atmospheric pressure. The detailed procedure is:

Step 1 - Prepare and test the DTC-II in accordance with Section 3 and maintain standard ambient temperature during the entire test.

Step 2 - Decrease the chamber pressure to 141.2 mm of Hg (5.558 inches of Hg or 40,000 feet above sea level) at a rate not to exceed 2,000 fpm. Maintain this pressure for not less than 8 hours.

Step 3 - With the DTC-II not operating, return the chamber to standard ambient conditions at a rate not to exceed 2,000 fpm.

Step 4 - Operate and inspect the DTC-II and obtain results in accordance with Section 3.

3.4 HUMIDITY TEST

The humidity test shall follow the procedures in MIL-STD-810, Method 507.2, Procedure III, as specified in MIL-E-16400. This procedure exposes the test item to more extreme temperature and humidity levels than those found in nature but for shorter durations. It is used to reduce the time and cost of testing. This test entails 10 cycles of 1 day each, with 30°C, 85% or more RH and 60°C, 95% RH extremes. The detailed procedure is:

Step 1 - Prepare the DTC-II in accordance with Section 3.

Step 2 - Adjust the chamber to controlled ambient conditions and maintain for 24 hours.

Step 3 - Test the DTC-II in accordance with Section 3.

NOTE: The DTC-II may be readjusted or realigned as necessary to conform to the equipment specification requirements. No further realignment or readjustment shall be permitted throughout the test period other than with accessible controls, external to the DTC-II, employed for operation of the DTC-II. If repairs, replacement of parts, or adjustments other than by the accessible external controls are made at any time prior to completion of the measurements required at the end of the fifth cycle, all five of the 24-hour cycles shall be repeated. Repairs include any change to the DTC-II that is not made by use of the accessible controls external to the DTC-II. The DTC-II shall only be operated when specified test measurements are being performed.

Step 4 - Gradually raise the internal chamber temperature to 60°C (140°F) and the relative humidity to 95% ± 5% over a period of 2 hours.

Step 5 - Maintain the conditions of step 4 for not less than 6 hours.

Step 6 - Maintain 85% or greater relative humidity and reduce the internal chamber temperature in 8 hours to 30°C (86°F) and 95% ± 5% relative humidity.

Step 7 - Maintain the 30°C (86°F) and 95% ± 5% relative humidity for an additional 8 hours.

Step 8 - Repeat steps 4, 5, 6, 7 for a total of 10 cycles (not less than 240 hours).

Step 9 - Near the end of the fifth and tenth cycles, while still at 30°C (86°F) and 95% relative humidity, operate the DTC-II and obtain and record results in accordance with Section 2.

Step 10 - Inspect the DTC-II in detail to detect evidence of physical degradation (such as corrosion of metal parts, distortion of plastic parts, and insufficient lubrication of moving parts) in accordance with Section 3. Blistering of organic coatings shall be a cause for rejection

Step 11 - If difficulties are encountered using Procedure III, perform the longer, less extreme humidity test following the procedures in MIL-STD-810, Method 507.2, Procedure II—Induced, Hot-Humid (Cycle 4) as specified in MIL-E-16400. This test entails 15 cycles of 1 day each, with 33°C, 80% RH and 71°C, 14% RH extremes. The detailed procedure is:

Step 1 - Prepare the DTC-II in accordance with Section 3.

Step 2 - Adjust the chamber to controlled ambient conditions and maintain for 24 hours.

Step 3 - Test the DTC-II in accordance with Section 3.

NOTE: The DTC-II may be readjusted or realigned as necessary to conform to the equipment specification requirements. No further realignment or readjustment shall be permitted throughout the test period other than with accessible controls, external to the DTC-II, employed for operation of the DTC-II. If repairs, replacement of parts, or adjustments other than by the accessible external controls are made at any time prior to completion of the measurements required at the end of the fifth cycle, all five of the 24-hour cycles shall be repeated. Repairs include any change to the DTC-II that is not made by use of the accessible controls external to the DTC-II. The DTC-II shall only be operated when specified test measurements are being performed.

Step 4 - Adjust the temperature and relative humidity to those shown in MIL-STD-810, table 507.2-2, Hot-Humid (Cycle 4) or its approximated curves of figure 507.2-2 (included as table B-1 and figure B-1) for time 0000.

Step 5 - Cycle the chamber air temperature and RH with time as shown for Cycle 4 in table B-1 or figure B-1 through the 24-hour cycle.

Step 6 - Repeat step 5 for a total of 15 cycles.

Step 7 - At the low-temperature point in the fifth and tenth cycles, while still at and near chamber set point conditions, operate the DTC-II and obtain and record results in accordance Section 3.

Step 8 - Inspect the DTC-II in detail to detect evidence of physical degradation (such as corrosion of metal parts, distortion of plastic parts, and insufficient lubrication of moving parts) in accordance with Section 3. Blistering of organic coatings shall be a cause for rejection.

3.5 SALT FOG TEST

The salt-fog test is conducted to determine the resistance of the unit under test to the effect of a salt atmosphere. The salt-fog test, Method 509.2 of MIL-STD-810 as specified by MIL-E-16400 for sheltered equipment, shall be applied to the finishes and coatings on parts and frame and enclosure structures as finally assembled for use. Sample corner structures and other critical sections may be used for the test. The test shall not be applied to the complete equipment. After the test, items are compared with their pretest condition. No base metal should be visible through the structure's finish.

Table B-1. High-humidity diurnal categories.

Time	Natural								Induced					
	Hot-Humid (Cycle 1)			High Humidity Constant (Cycle 2)		High Humidity Cyclic (Cycle 3)			Hot Humid (Cycle 4)			Cyclic High Humidity (Cycle 5)		
	Temp °F	°C	RH %	Temp °F °C	RH %	Temp °F	°C	RH %	Temp °F	°C	RH %	Temp °F	°C	RH %
0000	88	31	88	Nearly constant at 24°C (75°F) throughout the 24 hours.	100[2]/	80	27	100	95	35	63	91	33	68
0100	88	31	88		100	80	27	100	95	35	67	91	33	69
0200	88	31	88		100	79	26	100	94	34	72	90	32	70
0300	88	31	88		100	79	26	100	94	34	75	90	32	71
0400	88	31	88		100	79	26	100	93	34	77	88	31	72
0500	88	31	88		100	78	26	100	92	33	79	86	30	74
0600	90	32	85		100	78	26	100	91	33	80	88	31	75
0700	93	34	80		98	81	27	94	97	36	70	93	34	64
0800	96	36	76		97	84	29	88	104	40	54	101	38	54
0900	98	37	73		95	87	31	82	111	44	42	107	42	43
1000	100	38	69		95	89	32	79	124	51	31	113	45	36
1100	102	39	65		95	92	33	77	135	57	24	124	51	29
1200	104	40	62		95	94	34	75	144	62	17	134	57	22
1300	105	41	59		95	94	34	74	151	66	16	142	61	21
1400	105	41	59		95	95	35	74	156	69	15	145	63	20
1500	105	41	59		95	95	35	74	160	[illegible]	14	145	63	19
1600	105	41	59		95	93	34	76	156	[illegible]	16	144	62	20
1700	102	39	65		95	92	33	79	151	66	18	140	60	21
1800	99	37	69		95	90	32	82	145	63	21	134	57	22
1900	97	36	73		97	88	31	81	136	58	29	122	50	32
2000	94	34	79		98	85	29	91	122	50	41	111	44	43
2100	91	33	85		100	83	28	95	105	41	53	101	38	54
2200	90	32	85		100	82	28	96	103	39	58	95	35	59
2300	89	32	88		100	81	27	100	99	37	62	93	34	63

[1]Temperature and humidity values are for ambient air.

[2]For chamber control purpose, 100% RH implies as close to 100% as possible but not less than 95%.

Step 1 - Prepare salt solution as follows.

Preparation of salt solution. The salt used shall be sodium chloride containing on the dry basis not more than 0.1% sodium iodide and not more than 0.5% of total impurities. Unless otherwise specified, a 5±1% solution shall be prepared by dissolving five parts by weight of salt in 95 parts by weight of distilled or demineralized water. The solution shall be adjusted to and maintained at a specific gravity between the limits shown on figure 509.2-3 of MIL-STD-810 by using the measured temperature and density of the salt solution. Sodium tetraborate (common borax) may be added to the salt solution as a pH stabilization agent in a ratio not to exceed 0.7g sodium tetraborate to 75 liters of salt solution.

The pH of the salt solution, as collected as fallout in the exposure chamber is to be maintained between 6.5 and 7.2 with the solution temperature at +35°C (+95°F). Only diluted chemically pure hydrochloric acid or chemically pure sodium hydroxide shall be used to adjust the pH. The pH measurement shall be made electrometrically or colorimetrically.

Step 2 - Unless the chamber has been used within 5 days, immediately before the test and with the exposure chamber empty, adjust all test parameters to those required for the test. Maintain these conditions for one 24-hour period. Continuously monitor all test parameters to verify that the test chamber is operating properly.

Step 3 - Prepare the test item(s) in standard configuration used in the DTC-II.

Step 4 - Record the room ambient conditions.

Step 5 - Conduct a complete visual or photographic examination of the test item(s) with attention to:

a. High-stress areas;

b. Areas where dissimilar metals are in contact;

c. Electrical and electronic components—especially those having closely spaced, unpainted, or exposed circuitry;

e. Metallic surfaces;

f. Components or surfaces provided with coatings or surface treatments for corrosion protection; and

g. Electrical or thermal insulators.

Step 6 - Place the DTC-II test item(s).

Step 7 - Adjust the test chamber temperature to 35°C (95°F) and condition the test item for at least 2 hours before introducing the salt fog.

Step 8 - Continuously atomize the salt solution prepared in Step 1 into the test chamber for a period of 48 hours. During the entire exposure period, the salt-fog fallout rate and pH of the fallout solution shall be measured at least at 24-hour intervals. More frequent intervals are recommended. If fallout quantity requirements are not met, that interval must be repeated.

Step 9 - Store the test item in a standard ambient atmosphere for 48 hours, or as specified in the equipment specification, for drying.

Step 10 - Inspect the DTC-II test item(s) for corrosion.

> NOTE: If necessary to aid in examination, a gentle wash in running water not warmer than 38°C (100°F) may be used.

3.6 VIBRATION TEST

Both DTC-II units shall be vibration tested following the procedures of MIL-STD-167-1 type I, between 5 and 50 Hz. Please note that "resonance" is defined as the frequency at which a peak amplitude of motion is observed, and where any change in frequency causes a decrease in response. The unit will be mounted to the vibration table, similar to its mounting aboard ship.

> NOTE: Subject the DTC-II to a simulated environmental vibration as may be encountered aboard naval ships. Unwanted structural arrangements on-board ship will cause the amplitudes of vibration to be magnified and, therefore, many items of the DTC-II may be subjected to more severe vibrations than those imposed by normal hull vibrations or the levels designated by this standard. In addition, while normal vibration trials are conducted in quiet water to achieve repeatable and reliable results, actual ship operations occur in all sea states and headings with correspondingly large increases in vibration over long periods of time. Consequently, the requirements specified herein account for these increased vibrations by being more stringent than the minimal ones usually reported. This standard provides an amplitude sufficiently large within the selected frequency range to obtain a reasonably high degree of confidence that the DTC-II will not malfunction during service operation.

Detailed procedures are as follows:

Step 1 - Perform the vibration tests by means of any testing machine capable of meeting the conditions specified in 4.1.3.3 of MIL-STD-167-1(SHIPS). Provide means for controlling the direction of vibration of the testing machine and for adjusting and measuring its frequencies and amplitude of vibration to keep them within prescribed limits. If the lower frequency limit of 4 Hz cannot be reached, the lowest attainable frequency may be used provided the natural frequencies of the equipment in translational and rocking modes of vibration do not lie below the lowest frequency of the available testing machine. This may sometimes be determined by properly controlled transient excitation, such as bumping the DTC-II to see whether low-frequency resonances exist. In no case shall a vibration testing machine be used that has a minimum frequency greater than 10 Hz.

Step 2 - For all tests, secure the DTC-II to the mounting bracket of the testing machine in the same manner that it will be secured on shipboard. In case alternate methods of mounting are specified, use each method of mounting. If the DTC-II is designed to be secured to a deck and a head-brace support, use a vertical bracket to simulate a bulkhead. The bracket shall be sufficiently rigid to insure that its motion will be essentially the same as the motion of the platform of the testing machine.

Step 3 - If the DTC-II is designed for permanent or semipermanent attachment to ship structure, attach it to ration testing machines in the same manner it is attached to the ship. Secure the DTC-II (if it is not designed for permanent or semipermanent attachment) to the testing machine by means of suitable straps.

Step 4 - Install the DTC-II on vibration testing machines in such a manner that the direction of vibration will be in turn along each of the three rectilinear orientation axes of the DTC-II as installed on shipboard—vertical, athwartship, and fore and aft. On a horizontal vibration testing machine, the DTC-II may be turned 90° in the horizontal plane in order to vibrate it in each of the two horizontal orientations. Do not install the DTC-II in any other way than its normal position.

> NOTE: Is the DTC-II is to be installed on resilient mounts meeting the requirements of MIL-M-17185 or on distributed isolation material (DIM), test without mounts? If the DTC-II incorporates other resilient mountings integrally in the DTC-II equipment box (such as electronic cabinets), install as supplied.

Step 5 - Prepare and test the DTC-II in accordance with Section 3.

Step 6 - Conduct each of the tests specified herein separately in each of the three principal directions of vibration. Complete all tests in one direction before proceeding to tests in another direction. Secure the DTC-II to the vibration table and energize to perform its normal functions. If major damage occurs, discontinue the test, repeat the entire test following repairs, and correct deficiencies, unless otherwise directed by the responsible agency. The manufacturer may, at his option, substitute an entirely new DTC-II for retest. If this option is taken, it shall be noted in the test report.

Step 7 - To determine the presence of resonances in the DTC-II, secure the DTC-II to the vibration table and vibrate it at frequencies from 4 Hz (or lowest attainable frequency) to 33 Hz, at a table vibratory single amplitude of 0.010 ± 0.002 inch. For frequencies from 34 to 50 Hz, use a table amplitude of 0.003 plus zero minus 0.001 inch. Make the change in frequency in discrete frequency intervals of 1 Hz and maintain at each frequency for about 15 seconds. Note the frequencies and locations at which resonances occur.

Step 8 - Vibrate the DTC-II from 4 Hz (or lowest attainable frequency) to 50 Hz in discrete frequency intervals of 1 Hz at the amplitudes shown in MIL-STD-167-1, table I (included as table B-2). At each integral frequency, maintain the vibration for 5 minutes.

Step 9 - Vibrate the DTC-II for a total period of at least 2 hours at the resonant frequencies chosen by the test engineer. If no resonance is observed, perform this test at 50 Hz or at the upper frequency. The amplitudes of vibration shall be in accordance with table B-2.

Step 3 - (medium weight). Perform tests for medium-weight equipment on the medium-weight shock machine. The mode of equipment operation during the tests shall be energized. Apply a minimum of nine blows consisting of three groups of three each (two sets of three blows inclined to simulate shipboard shock loadings in both horizontal directions). For each group, the height of hammer and the initial up travel of the anvil table shall be as shown in table 1 of MIL-S-901 (table B-3). Two blows of each group shall be with the DTC-II mounted on an inclined orientation. The fixture used shall conform to the requirements specified in 3.1.6.2.3 (MIL-S-901{NAVY}) and should be similar to the fixture shown on figure 16 (MIL-S-901C{NAVY}).

Step 4 - Tighten all mounting bolts of the DTC-II and shock machine mounting before each blow only as necessary to compensate for the loosening due to seating of the mating surfaces. Excessive bolt yielding or loosening shall be considered as cause for rejection.

Step 5 - Prepare and test the DTC-II in accordance with Section 3.

Step 6 - Record the behavior of the DTC-II for each test blow. After each blow and upon completion of the test, the DTC-II shall be operated and inspected and results obtained in accordance with Section 3.

Table B-3. Test schedule for medium-weight shock machine.

Group number	I	II	III
Number of blows	3	3	3
Anvil table travel, inches	3	3	1-1/2
Total weight on anvil table, 1 (Pounds)	Height of hammer drop 2 (Feet)		
250 - 1,000	0.75	1.75	1.75
1,000 - 2,000	1.00	2.00	2.00
2,000 - 3,000	1.25	2.25	2.25
3,000 - 3,500	1.50	2.50	2.50
3,500 - 4,000	1.75	2.75	2.75
4,000 - 4,200	2.00	3.00	3.00
4,200 - 4,400	2.00	3.25	3.25
4,400 - 4,600	2.00	3.50	3.50
4,600 - 4,800	2.25	3.75	3.75
4,800 - 5,000	2.25	4.00	4.00
5,000 - 5,200	2.50	4.50	4.50
5,200 - 5,400	2.50	5.00	5.00
5,400 - 5,600	2.50	5.50	5.50
5,600 - 6,200	2.75	5.50	5.50
6,200 - 6,800	3.00	5.50	5.50
6,800 - 7,400	3.25	5.50	5.50

[1]Total weight on anvil table is the sum of the DTC-II's weight plus the weight of mounting.
[2]Measure the height of hammer drop by means of the existing markings on the scale of the machine, no corrections being made for the added anvil table travel for the blows of groups I and II.

3.8 INCLINATION TEST

The DTC-II shall be subjected to dynamic inclination about both of its major horizontal axes while operating. Angles of inclination will be 30 degrees with a rate of 5 to 9 cycles per minute and an elapsed time of 3 minutes in each axis as specified in MIL-E-16400(NAVY).

Step 1 - Mount the DTC-II as specified in the equipment specification.

Step 2 - Prepare and test the DTC-II in accordance with Section 3.

Step 3 - Incline the DTC-II at the rate of 5 to 7 cycles per minute in one plane to angles of 45 degrees on either side of the vertical for a period sufficiently long to determine the characteristics under such motion or for a minimum of 30 minutes with the power on.

Step 4 - Repeat step 3 with the power off and equipment with drawer slides extended.

Step 5 - Test the DTC-II in accordance with Section 3.

Step 6 - Repeat steps 2, 3, 4, and 5 with the DTC-II reoriented 90 degrees to the plane in which it was originally tested.

Step 7 - At the conclusion of these cyclic tests, stop the cyclic motion.

Step 8 - Adjust the inclination to an angle of 15°.

Step 9 - Operate the DTC-II for a sufficient period to ensure that continuous operation can be maintained.

Step 10 - Repeat steps 8 and 9 after rotating the inclination through the vertical to 15° in the opposite direction.

Step 11 - Reorient the DTC-II 90° and repeat steps 8, 9 and 10.

NOTE: For submarine installation, maximum angle shall be 60°.

3.9 ENCLOSURE TEST

The DTC-II units shall be examined visually only, since they are determined to have an "open, protected" degree of enclosure. This type of enclosure "provides limited environmental protection and permits free transmission of air." The units will be examined to assure that the enclosures offer impediments to "gross accidental contact by personnel or equipment" (e.g., spilled coffee). The detailed procedure is:

NOTE: Visual examination or actual drip test may be used to determine the ability of the enclosed DTC-II to operate satisfactorily under the defined conditions. Visual examination is intended to determine the ability of the enclosure to exclude falling drops of liquid or solid particles. Such exclusion is not necessarily required of the enclosure. If the enclosed is of such design that falling drops of liquid or solid particles appear to be able to enter, the ability of the enclosed DTC-II to operate satisfactorily under the defined conditions can be determined only by further examination of the DTC-II within the enclosure or by actual drip test.

Step 1 - Visual examination. Examine enclosed DTC-II visually for the presence of the following features and characteristics when in its normal position or inclined in any direction at angles not exceeding the specified 45°.

(a) There are no openings directly exposed to falling drops of water or solid particles. Openings where provided on exposed surfaces shall be protected by louvers or suitably covered.

(b) All removable plates or covers on enclosure surfaces exposed to falling drops of water shall have gaskets. Doors and door openings on exposed enclosure surfaces shall be of such design as to prevent the entry of falling drops of water.

(c) There shall be no paths on the surface of the enclosure that drops of liquid or solid particles will follow and run into the enclosure.

3.10 TRANSIENT VOLTAGE TEST (MIL-STD-1399(NAVY), SECTION 300A, MODIFIED)

Step 1 - With the DTC-II operating at the upper limit of steady state voltage, a transient voltage of plus 10% of nominal voltage recovering to the steady state voltage within 2s shall be superimposed. The DTC-II shall be capable of normal operation following the transient.

Step 2 - With the DTC-II operating at the lower limit of steady state voltage, a transient voltage of minus 10% of nominal voltage recovering to the steady state voltage within 2s shall be superimposed. The DTC-II shall be capable of normal operation following the transient.

3.11 TRANSIENT FREQUENCY TEST (MIL-STD-1399(NAVY), SECTION 300A, MODIFIED)

Step 1 - With the DTC-II operating at 5% above the nominal frequency, increase the frequency by an additional 3%, recovering to the steady state frequency (±5% of normal) within 2s. The DTC-II shall be capable of normal operation following the transient.

Step 2 - With the DTC-II operating at 5% below the nominal frequency, increase the frequency (±5% of normal) within 2s. The DTC-II shall be capable of normal operation following the transient.

3.12 TRANSIENT VOLTAGE AND FREQUENCY TEST

The DTC-II performance shall be evaluated under the transient frequency and voltage conditions specified in MIL-STD-1399(NAVY), SECTION 300A, Paragraph 5.3.2 for Type I power +20% V, +5 1/2% frequency. The detailed procedure is:

Step 1 - The DTC-II shall be operated in a normal mode within the user voltage and frequency tolerance envelope as shown on MIL-STD-1399(NAVY), SECTION 300A(NAVY) (figure B-2) until the equipment temperatures have stabilized.

Step 2 - The power input voltage and frequency shall be suddenly changed from nominal to the upper limit, then returned to nominal in 2 seconds. Operation after completion of the transient shall be normal, as before the transient.

Step 3 - Repeat step 2 except for the lower limit of the power input voltage and frequency.

Step 4 - Repeat Steps 1, 2, and 3 for all other normal modes of operation, if any.

3.13 SPIKE VOLTAGE TEST (MIL-STD-1399(NAVY), SECTION 300A)

Step 1 - Subject the DTC-II to an input supply-line voltage spike of 1000-V positive peak amplitude; the wave shape shall correspond with that of the figure for the "spike voltage (short time transient) wave shape," as shown in MIL-STD-1399(NAVY), SECTION 300A (figure B-2).

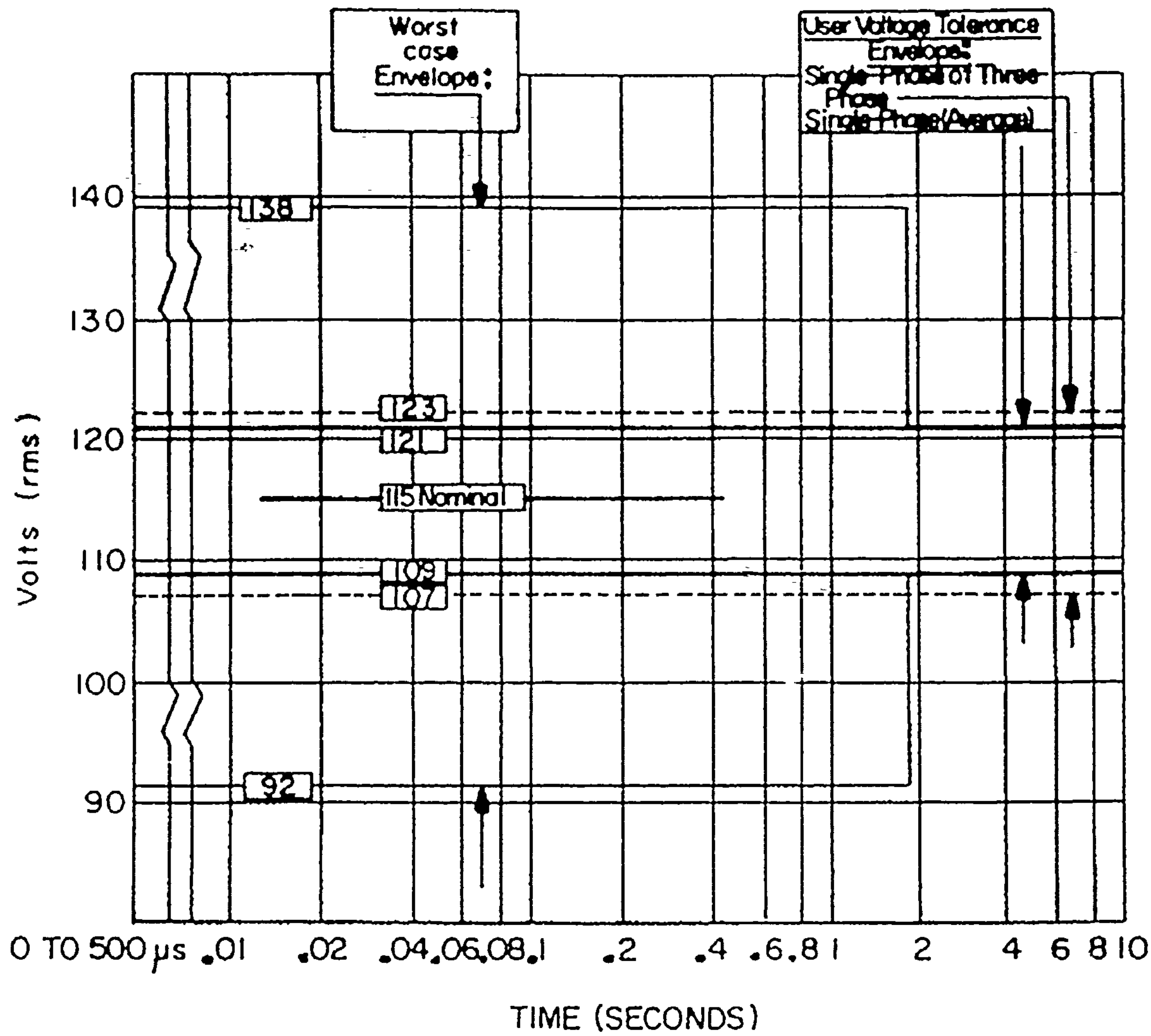

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Figure B-2. Types I and II, 115-V power—worst case and user voltage envelopes.

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